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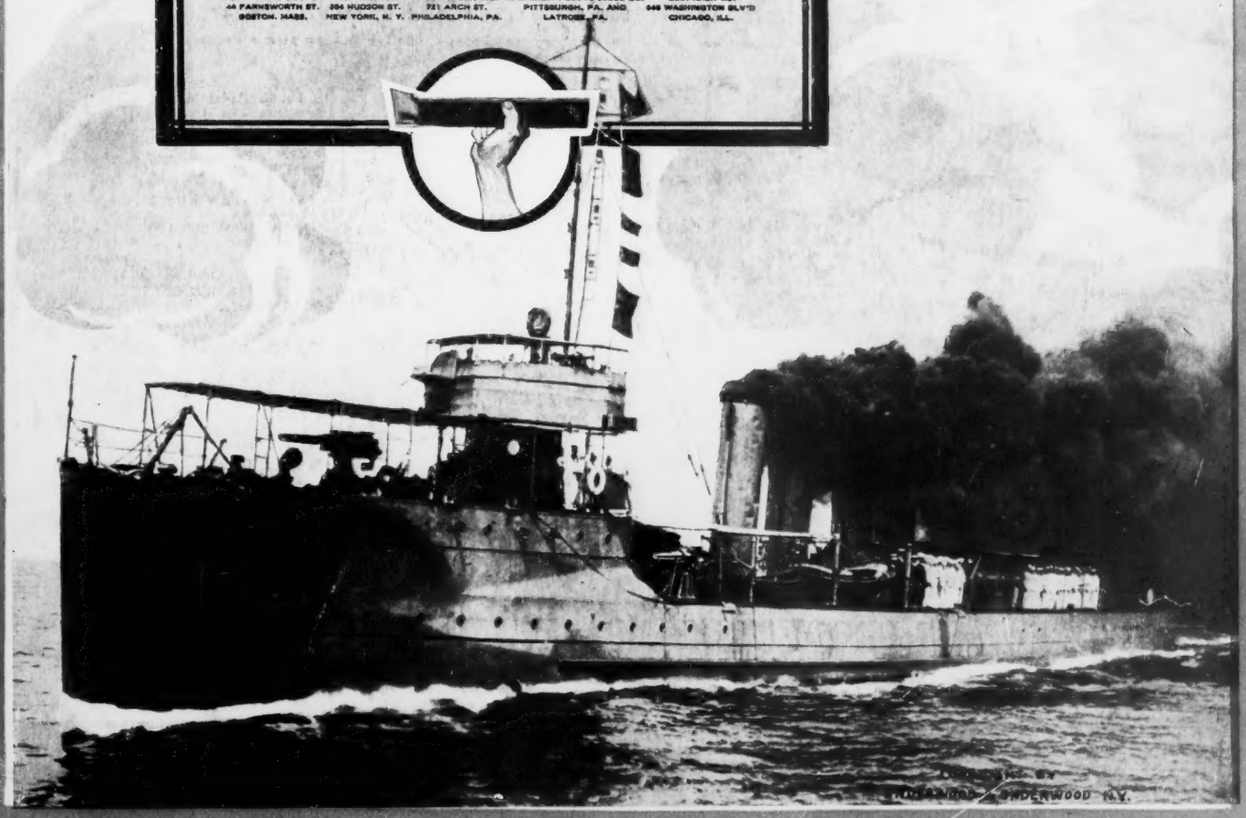

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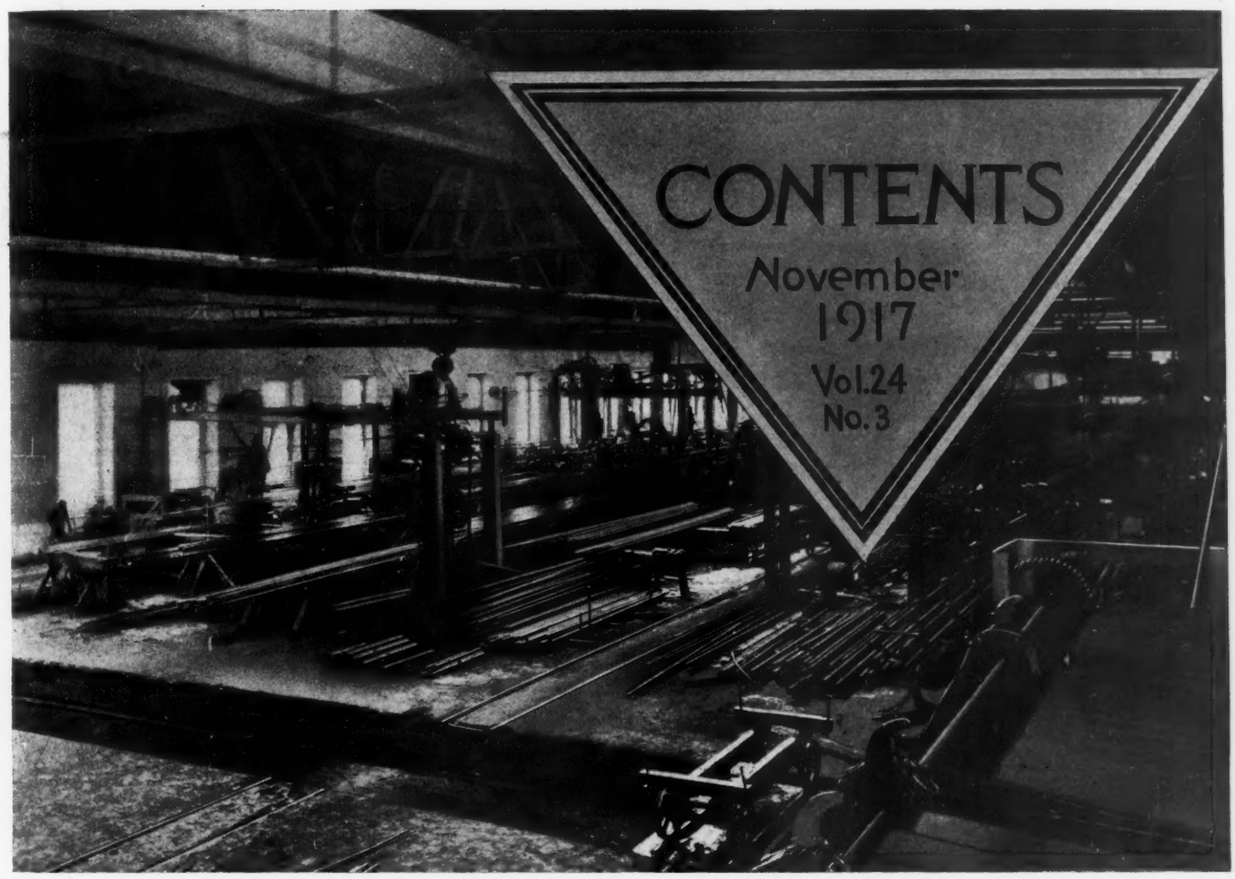

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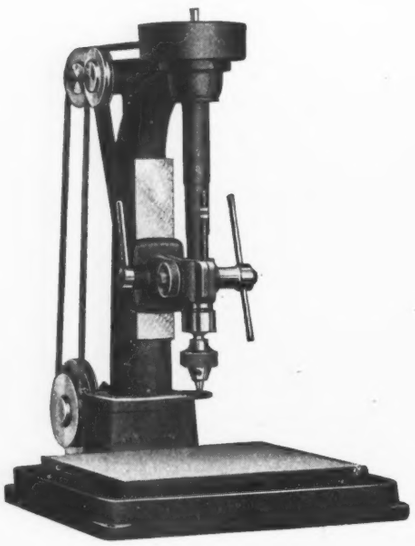

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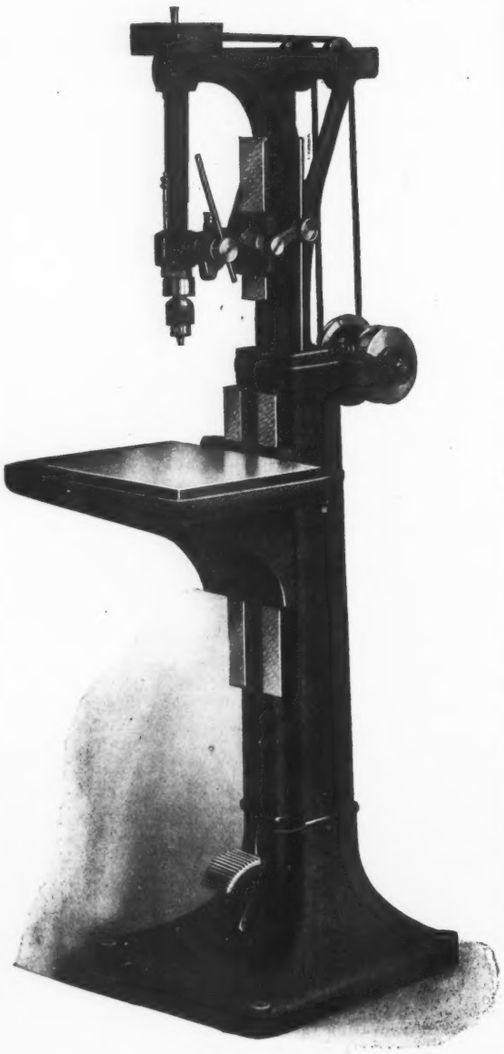

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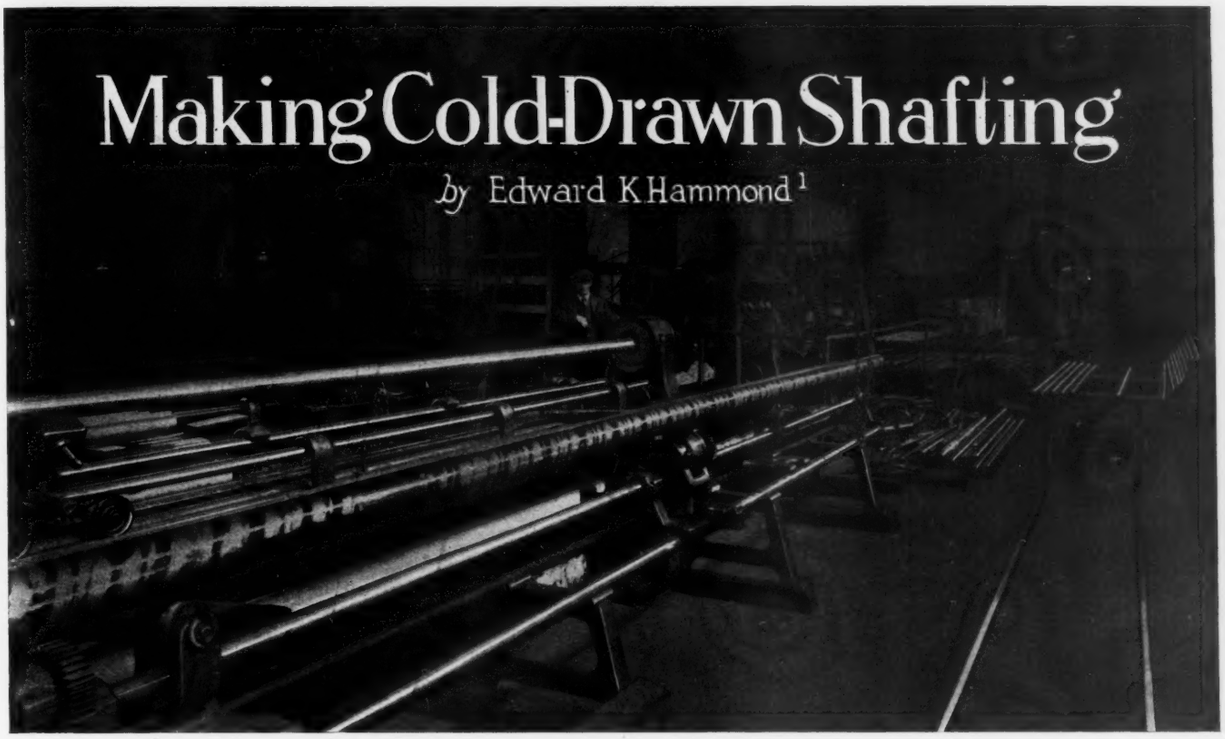
NOVEMBER MACHINERY 1917

Making Cold-Drawn Shafting

by Edward K Hammond[1]



The manufacture of cold-drawn shafting is essentially wire drawing on a large scale. The shafts are pulled through dies by draw-benches or bull-block machines. The preparation of the stock, pointing of the bars, draw-benches and bull-block machines, speed of drawing, power required for cold-drawing, dies used for drawing wire and small sizes of screw stock and shafting, dies for drawing square, rectangular and other shapes, lubricants for drawing, speed of production, straightening, and other features of practice are treated in the following article.

THE terms "cold-drawn" and "cold-rolled" are indiscriminately applied to all grades of shafting and screw stock with a bright finish; but as a matter of fact these two processes are entirely distinct. Cold-drawn shafting and screw stock are made by drawing the steel bar through a die, which reduces the diameter to exactly the required size and imparts a high finish to the surface of the metal; and cold-rolled shafting is made by turning the bar to just about the required diameter and then obtaining the final reduction and finish by passing it through a machine equipped with burnishing rolls. It will be evident from this that the rolling process is very different from the method of treatment to which steel is subjected when it is rolled hot to reduce the diameter and increase the length of the bar. Either cold-drawing or cold-rolling imparts a hard surface to the steel and increases the tensile strength of the bar. In addition to cold-drawing and cold-rolling, there is a third method which finds general application in the production of shafting over three inches in diameter; this consists of simply turning the bar down to the required diameter, taking particular care to take a light finishing cut that will leave the surface as smooth and uniform as possible. Most shafting and screw stock up to three inches in diameter is cold-drawn, and shafting above that size is generally turned.

Raw Material of the Industry

Cold-drawn shafting is made from an open-hearth steel containing about 0.15 per cent carbon, which is similar to the grade commonly known as "machinery" steel. In most plants engaged in the manufacture of cold-drawn shafting, the raw material is purchased from the steel mill in the form of bars having a diameter from 1/32 to 1/8 inch larger than the shafting to be drawn, the amount of excess metal increasing with the size of the work; but as the production of this raw material is an important part of the shafting industry, a brief description of the method employed will be given.

[1]Associate Editor of MACHINERY

Molten steel, which has been brought to the required chemical composition by refining in an open-hearth furnace, is poured into ingot molds that produce ingots ranging from 16 to 20 inches square by 4 to 5 feet in length, weighing approximately 3200 to 6250 pounds. These are the regular steel works ingots that might ultimately be worked up into a variety of other products in addition to cold-rolled shafting. After being removed from the mold, the ingots are transferred to a blooming mill, in which they are rolled down into billets from 2 to 5 inches square, according to the size of the shafting to be made.

The next step in the process will depend upon the kind of shafting that is to be produced; but in any case the billets produced in the blooming mill are cut up into pieces of such a length that they can be rolled out into bars of the same length as the shafting to be drawn. In most cases the length of billet is such that the rolled bars will be from 30 to 40 feet in length, as this is the greatest length that can be handled in an ordinary freight car. The billets are reheated and then rolled down into bars of this length, of a diameter slightly larger than the required size of the shafting.

Pickling Hot-rolled Bars

The steel bars that the shafting factory purchases from the steel mill have been rolled hot, and as a result they are covered with an oxide scale, which must be removed before the bars can be converted into cold-drawn shafting. The reason for this is that the oxide scale is extremely hard and would rapidly destroy the drawing dies; also, cold-drawn shafting is required to have what is known as a "bright" finish, and this can only be obtained when the metal is free from oxide. Another reason for removing every particle of scale from the bars before they are drawn is that, if it were not removed, small pieces of scale would be driven into the steel by the die pressure and cause flaws that would seriously reduce its strength. The first step in cleaning or "pickling" the metal is to place the bars of steel in wooden troughs containing a 5 per cent solution of commercial sulphuric acid, which has a

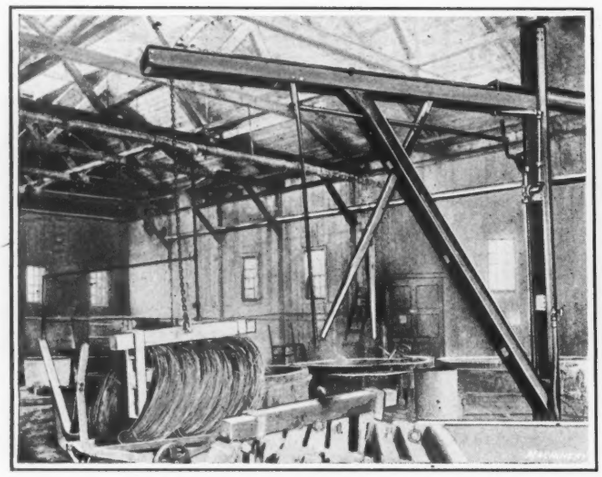


Fig. 1. Jib Crane with Yoke for holding Bundles of Wire to be dipped into Pickling Vats. Built by Morgan Construction Co.

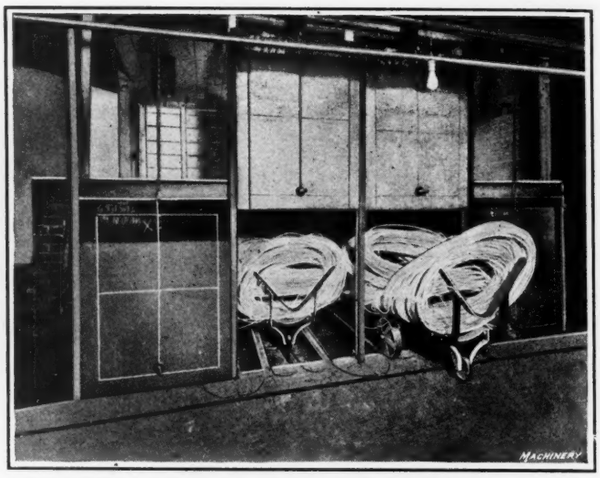


Fig. 2. Oven in which Truck-loads of Wire are dried after leaving Pickling Department. Built by Morgan Construction Co.

specific gravity of 66 degrees Baumé at a temperature of 60 degrees F. The scale is removed by a combined chemical and mechanical action; the acid reacts with the iron and liberates hydrogen, which collects under the oxide scale and develops sufficient pressure to tear away the scale in small plates. As the chemical action is accelerated by heat, the temperature of the acid bath is raised to about 180 or 200 degrees F. by means of pipes which deliver live steam into the trough.

A very little thought will make it evident that the shafting must be left in the acid bath only long enough to remove the scale, as, if it were left in longer than required, the steel would be eaten away and the diameter of the bars reduced so that they would be too small for making shafting of the size for which they are intended. It is particularly important to regulate the length of time the steel is left in the acid bath in the case of high-carbon steel, as experience has shown that the acid tends to decarbonize the steel at the surface. Low-carbon steel can be left in the bath for from twelve to fifteen minutes, and sometimes twenty minutes will not be too long; but high-carbon steel must not be exposed for more than four or five minutes. After being removed from the acid bath, the steel bars are rinsed in troughs containing pure water, after which they are transferred to troughs containing a solution of limewater, which has the property of neutralizing the acid and preventing further action of any slight trace of acid that may still adhere to the bars. The dipping of the bars in limewater also has a further valuable purpose: when removed from the bath the bars are covered with a solution of limewater, and after the water has dried off, this solution leaves a deposit of lime which protects the steel from oxidation by the oxygen in the atmosphere.

In order to prevent the steel from rusting, it is of the highest importance that the bars be dried quickly after they are removed from the limewater bath, and for this purpose the bath is maintained at a temperature of about 200 degrees F. by pipes which deliver live steam to the baths in the same way as in the acid bath. In the case of bars over 5/16 inch in diameter, the metal absorbs sufficient heat in the bath to evaporate the limewater solution rapidly and leave the dry coating of lime; but bars of smaller diameter than the size mentioned are put on a rack and heated by coils containing high-pressure steam so that the water is rapidly evaporated. In any case, it is absolutely necessary to have the lime "bone dry" at the time the bars are drawn through the dies, because if there is any moisture it will result in rapidly wearing out the dies and scoring the surface of the shafting so that its finish will not be satisfactory. Before being drawn, the bars are carefully inspected for seams and other surface defects, and those showing imperfections of this kind are rejected.

In pickling small sized stock, which is handled in coils, the method of procedure is somewhat different. Usually about eight coils are suspended on a yoke and dipped into a tub containing the pickling acid. Each bundle contains from 125 to 300 pounds of metal, and as the yoke loaded with eight coils is quite heavy, it is necessary to provide a crane for handling the metal. A jib crane is usually placed at the center of a circle of tubs. As in the case of straight bars, the steel is first pickled in acid, after which it is rinsed in a tub of water and immersed in limewater. Upon coming out of the lime bath, the bundles are placed on a truck and the yoke is removed. The truck load of steel is then run into a baking oven maintained at a temperature of 325 to 375 degrees F. and left there for a sufficient length of time to dry the metal completely. The steel is then removed from the oven and allowed to cool preparatory to being drawn.

Pointing Bars preparatory to Drawing

Before the cleaned steel bars can be subjected to the cold-drawing operation, it is necessary for them to be pointed at one end so that the point can be passed through the drawing die and gripped by the tongs of the draw-bench. The method of pointing varies according to the size of bars that have to be drawn, and practice in this connection also varies according to the shop in which the work is done. The general state-

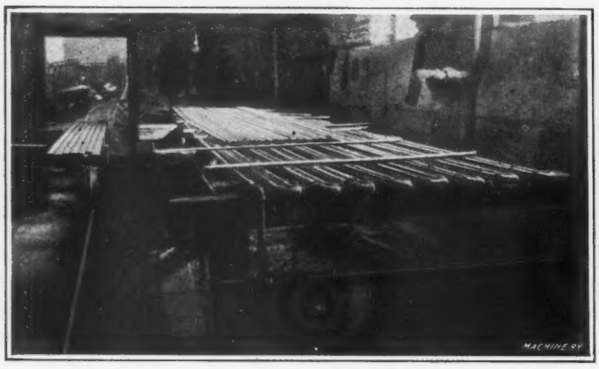


Fig. 3. Steam-heated Rack on which Straight Bars are dried after leaving Pickling Department

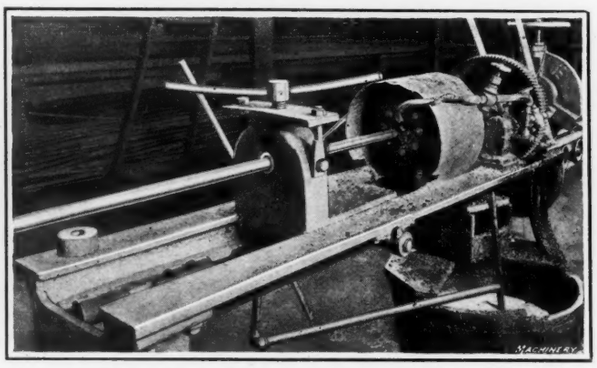


Fig. 4. Machine with Rotary Cutter-head for pointing Bars up to One Inch in Diameter Ready for Drawing Operation

ment may be made, however, that bars of the larger sizes are pointed in a machine equipped with a cutter-head that actually removes metal from the end of the bar. On smaller sized bars the pointing is done in a swaging or rolling machine, which hammers or rolls down the end of the bar to reduce its diameter sufficiently so that it will pass through the die and enable the tongs to take hold.

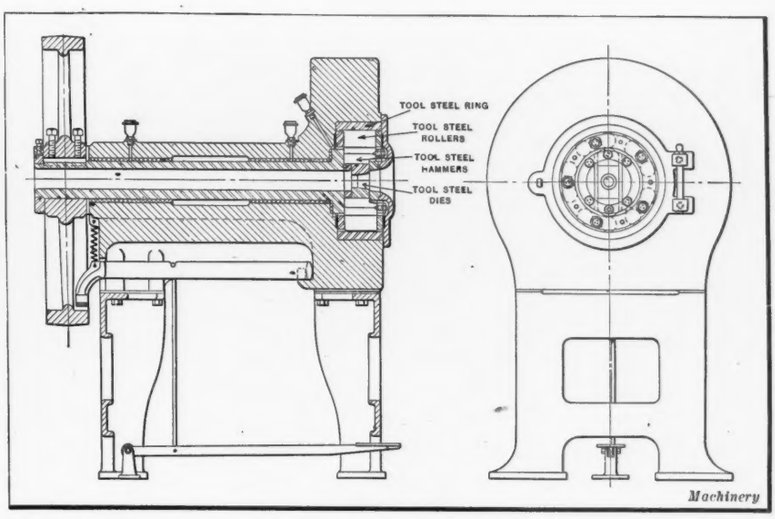


Fig. 5. Swaging Machine built by Standard Machinery Co. for pointing End of Bars Ready to start drawing

Rotary Swaging Machines

In Fig. 5 is shown a rotary swaging machine built by the Standard Machinery Co., Auburn, R. I. In this machine the dies are adjustable relative to each other and are carried in a revolving spindle. These dies are held between a pair of blocks with round faces or ends, the arrangement being shown in the illustration. Outside of the head end of the spindle there is an annular rack fitted with hardened tool-steel rollers, and the revolution of the spindle causes the dies and hammers to pass the successive pairs of rollers which are situated opposite each other. This action forces the dies inward through the slot in the spindle and causes them to come together on the work. The spindle is bored from front to back to enable the long steel bars to be fed through in order to have their ends pointed. The dies revolve rapidly around the work, which is held stationary, while the rollers revolve slowly, being moved only slightly during their contact with the blocks. On this account the blows of the hammers are evenly distributed over the work to be swaged.

Pointing Bars of Special Shape

Pointing round bars ready for the cold-drawing operation is a simple matter, because the shape of the work offers no particular difficulty; but it is necessary for the shape of the point to be the same as that of the bar which is to be drawn, so in the case of square, hexagon, flat and V-shaped bars, the point must be of the same shape as the finished bar. In order to secure this result special methods must be employed. One of the most satisfactory processes consists of heating the end of the bar and then gripping it on each side of the heated section by clamps on a machine which provides for pulling the bar sufficiently to "neck in" the heated section and point it. Probably few readers of MACHINERY have seen this method used, but there are many who have conducted tests on either the Riehle or the Olsen testing machine who will recall that in stretching hexagon and other shaped sections the neck produced holds the shape of the original bar. Where this method is employed for pointing bars ready for drawing, it is important not to exceed the elastic limit of the material, as such a condition would result in a rapid reduction of diameter. To overcome this condition, the operator of the machine has a sponge soaked in water, and as soon as he notices any tendency for the diameter of the bar to reduce rapidly at some point, he drops a little water on the metal so that the temperature is lowered and the metal hardens sufficiently to prevent further reduction in diameter at the point where the elastic limit has been exceeded.

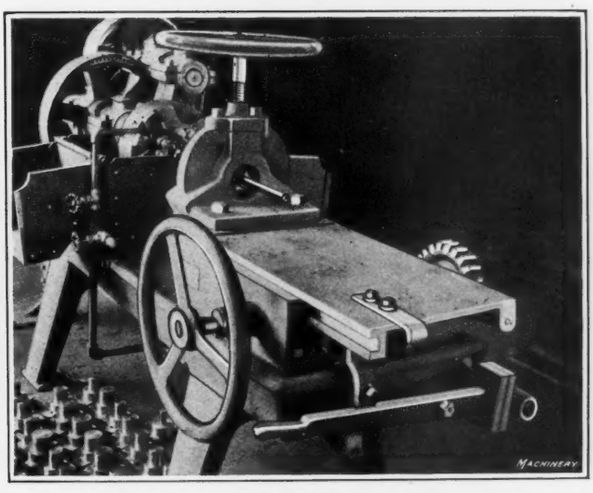


Fig. 6. Pointing Machine built by Brightman Mfg. Co.

Starting Bar through Die by Pushing

The carriage on a draw-bench is furnished with two serrated jaws that grip the work. These jaws are tapered on the outside and fit into a tapered holder on the carriage; the result is that when the jaws are pressed against the work and the carriage starts forward, they are drawn back in their tapered holder, which forces them to secure a firm grip on the work. For drawing stock over one inch in diameter, some manufacturers have their draw-benches equipped with an auxiliary carriage located behind the die-holder, which is fitted with a pair of tapered serrated jaws that can grip the work. Attached to this carriage is a yoke that drops over the die-holder so that a bar at the front end of the yoke may be gripped by the jaws of the regular draw-bench carriage. When the main carriage is started, this yoke draws the auxiliary carriage forward, which results in pushing the front end of the bar of steel through the die. Fig. 9 shows the apparatus after the bar has been pushed through the die and the yoke released from the jaws of the main carriage and raised by means of the cable and counterweight furnished for that purpose. The operator will now draw the main carriage back and grip the projecting end of the bar between its jaws; he will then release the jaws of the auxiliary carriage from the work and start the draw-bench, to pull the bar through the die. This is the means of saving the crop end of steel, which results through the customary practice of pointing the end of the bar so that it may be threaded through the die. On bars less than one inch in diameter this method cannot be used, because the bar buckles instead of being pushed through the die.

Cold-drawing Bars

Two important advantages are secured from the process of cold-drawing: First, the metal does not oxidize, because the work is done cold, and as a result the steel retains a so-called "bright" finish. Second, it is possible to hold the material within very close limits, the diameter of good cold-rolled shafting or screw stock being within 0.0005 inch of the specified diameter. The clean and extremely smooth finish produced in this way enables a high transmission efficiency to be obtained with cold-drawn shafting, as friction losses in bearings are reduced to a minimum. Advantage is taken of this method in producing material used for various other purposes, such as the manufacture of parts in automatic screw machines, etc., as it is found that the smooth finish and uniform diameter of cold-

rolled drawn bars enable them to be handled by automatic machinery with much better results; and advantage may also be taken of the high finish of the bar to avoid the necessity of further machining of surfaces where the original diameter of the bar meets all requirements. In this way a considerable saving is made in both material and production time.

In conducting the cold-drawing operation, the entire reduction is obtained by one passage of the steel through the drawing die. The amount of reduction obtained varies according to the diameter of the shafting which is being drawn, but for sizes 1/2 inch in diameter and over, a reduction of 1/16 inch may be obtained; and for smaller sizes of shafting the reduction is about 1/32 inch. In drawing some large sizes of shafting, a reduction as high as 1/8 inch is obtained. As a result, the bars of steel ordered from the rolling mill are specified to have a diameter which exceeds that of the shafting to be produced by the amount of reduction which may be obtained by one passage through the drawing die. The reductions referred to are for steel containing 0.15 per cent carbon; for high-carbon steel used in the manufacture of drill rod and certain other products, the amount of reduction possible by one passage through the dies is much less, as it is found that where the reduction is too great there is a tendency for the fibers of the metal to break and thus cause a serious reduction in the strength of the bars. As a result, the drawing of drill rod is conducted in such a way that a number of reductions are obtained by successive passages of the steel through the drawing dies until the diameter of the bar has been reduced to exactly the required size.

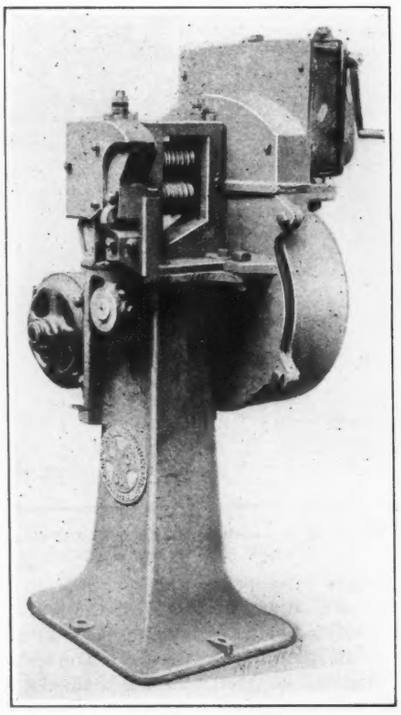


Fig. 7. Pointing Machine of Roll Type built by Morgan Construction Co. and equipped with Westinghouse Motor

Types of Draw-benches Used

Two types of machines are generally used for drawing shafting and screw stock. The first of these is known as the "straight draw-bench," on which a straight rod is drawn through the die by means of tongs on a head which travels straightways on the draw-bench, power being furnished by an endless sprocket chain or by hydraulic pressure. The second type is the bull-block machine, on which the rod is in the form of a coil that is carried on a reel at one end of the machine; the end of this rod is pointed and threaded through the drawing die and gripped by tongs carried on a second reel, which rotates in such a way that the rod is drawn through the die and wound up on the second reel. Both types of machines have points in their favor. The straight draw-bench is generally used for shaftings and rods from 7/8 inch diameter up; the most obvious advantage claimed for it is that the material is always straight, and consequently requires little treatment after the drawing operation has been completed. In contradistinction, the bull-block machine winds up the cold-drawn steel in a coil, which must be carefully straightened to prepare it for use. This takes time and involves an additional item of expense in the process of manufacture; but there are a number of factors in the bull-block machine that offset this expense, if they do not actually introduce a material factor of saving. In the first place, the material in coils is much more convenient to transport through the plant, as the stock can be carried on trucks and the plant does not have to be laid out in such a way that long bars can be handled conveniently. In the second place, it is possible to draw coils of steel weighing from 300 to 400 pounds and

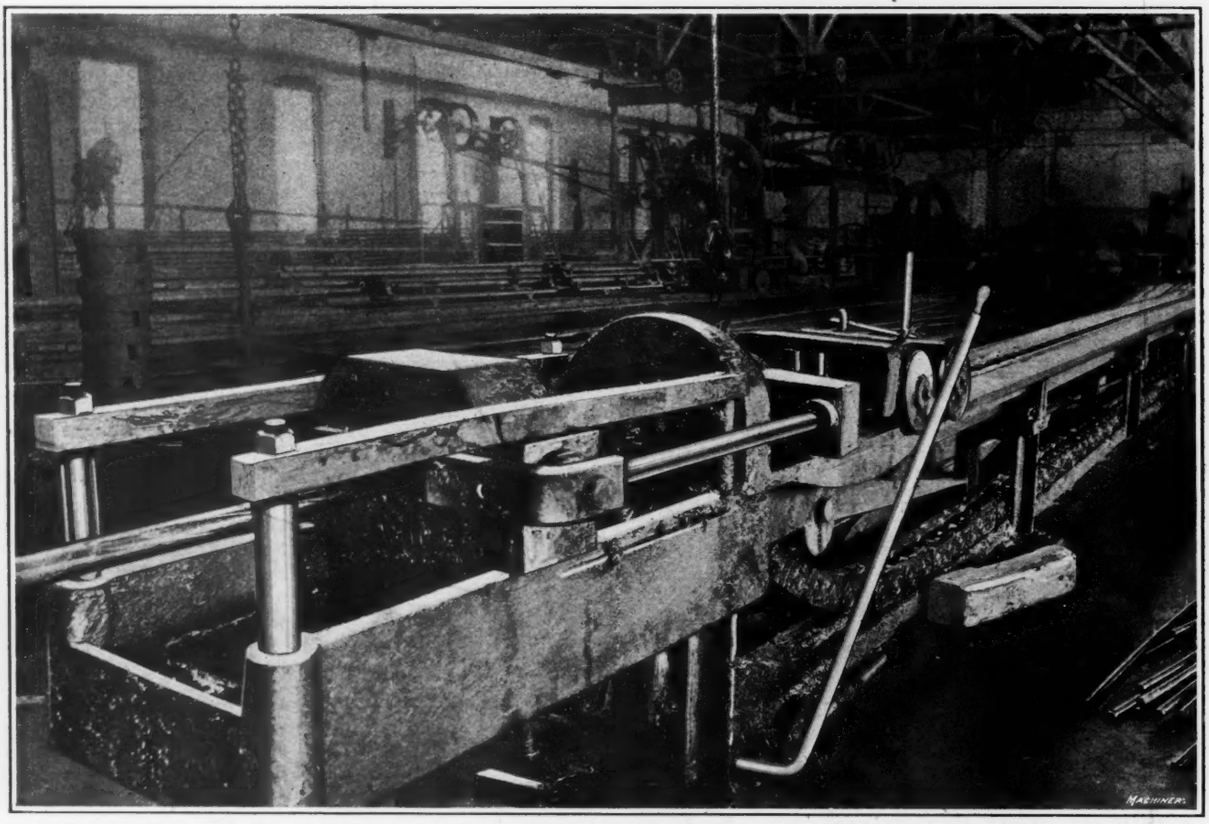


Fig. 8. Draw-bench equipped with Device for gripping Bar behind Die; Extension on Gripper is caught by Draw-bench so that End of Bar is pushed through Die Ready to be drawn

containing anywhere from 300 to 600 feet of rod, according to the diameter. This is the means of effecting a material saving in the cost of production, because the number of crop ends is materially reduced and the amount of metal going to the scrap pile is cut down to a minimum. In fact, this is the most important claim made for the bull-block machine, and at the present time many manufacturers are working on the idea that it may prove feasible ultimately to use coils containing as much as 1000 pounds of steel, so that scrap will be further reduced. The rate of production is also higher, because the time spent in setting up the machine is less where these long coils can be drawn at one continuous operation. Practice varies in different plants, but the general statement may be made that straight draw-benches are used for handling stock from 1/2 inch in diameter up, while bull-block machines are used for stock up to 1/2 inch. However, there are a number of cases in which bull-block machines have been successfully employed for drawing bars up to 7/8 inch diameter. Squares, rectangles, hexagons, octagons and other irregular shapes are being drawn on bull-blocks in addition to round stock.

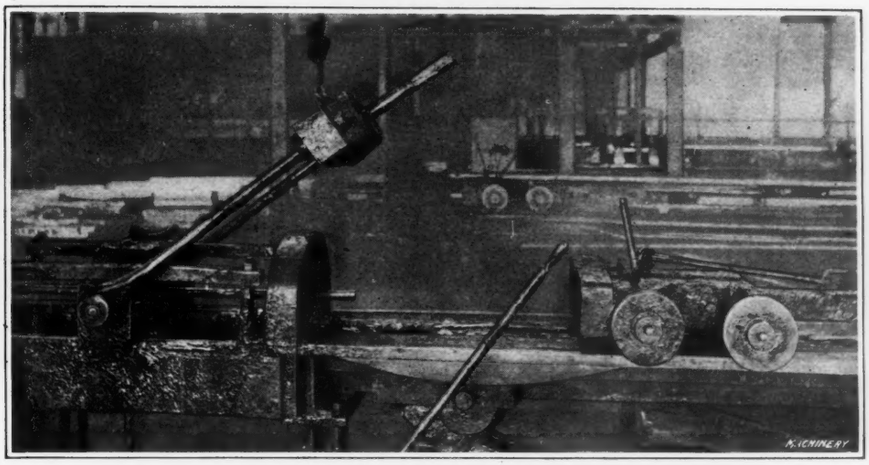


Fig. 9. View of Die from Front after End of Bar has been pushed through Die

Where the attempt is made to draw stock larger than 7/8 inch in diameter, trouble has sometimes been experienced through the tendency for the cross-section to be slightly distorted. For instance, in round stock the tendency is for the cross-section to become slightly elliptical. This is due to the fact that the material is being coiled on a comparatively small drum, and trouble of this kind is especially likely to happen when low-carbon steel is being drawn. Sometimes it has been found possible to compensate for this in the shape of the die or by employing special methods of straightening the stock. There is a wide difference of opinion, however, as regards the maximum diameter of stock that can be safely handled on rotary drawing machines. As previously stated, some manufacturers will not attempt to draw work over 1/2 inch, while others are successfully using machines of this type for drawing work up to round bars 7/8 inch in diameter.

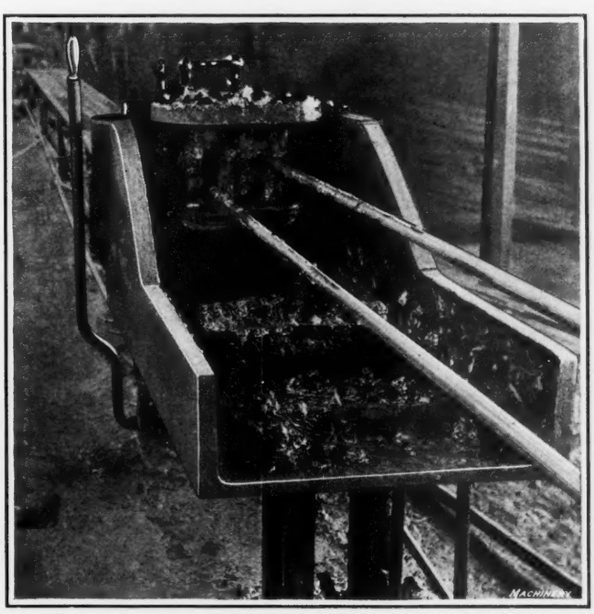


Fig. 10. View of Straight Draw-bench, showing Dies and Container for Supply of Lubricant

Speeds at which Drawing is Done

The speed at which cold-drawn steel stock or shafting is pulled through the die varies considerably with the size of the stock being drawn. The larger the diameter, the lower must be the rate at which it is drawn through the die. Bull-blocks or draw-benches are not arranged to give a variable speed, but the gearing and diameter of the blocks on a bench may be varied, thereby accomplishing the same results. Most steel mills drive their blocks with electric motors, a motor driving from one or two blocks up to any number within the range of its pulling capacity. At present the most approved practice seems to find thirty-six as the maximum number of blocks that can be pulled by one motor, but it must be borne in mind that this applies to the drawing of relatively small wire. About six blocks per motor represents the average number for wire 3/8 inch in diameter. The actual drawing speed varies from 250 to 375 feet per minute, according to the diameter of the wire and the character of the steel being drawn.

The following represents the practice of the Pennsylvania Shafting Co., Spring City, Pa., in drawing steel shafting on straight draw-benches. On a bench handling four bars at once, ranging from 7/16 to 1 inch in diameter, the speed at which the steel is drawn through the dies is 16 feet per minute. For stock from 1 1/16 to 2 inches in diameter, drawing one bar at a time, the speed is 16 feet per minute. When drawing steel from 2 inches in diameter to 3 1/4 inches, with one bar drawn at a time, the speed is 8 feet per minute. So much for the speeds of drawing round bars. Let us now turn our attention to the drawing of flats. In the case of bars ranging in size from 1/4 by 5 to 1 by 5 inches, and hexagons of about the same cross-sectional area, the speed of drawing is 11 feet per minute. In drawing bars

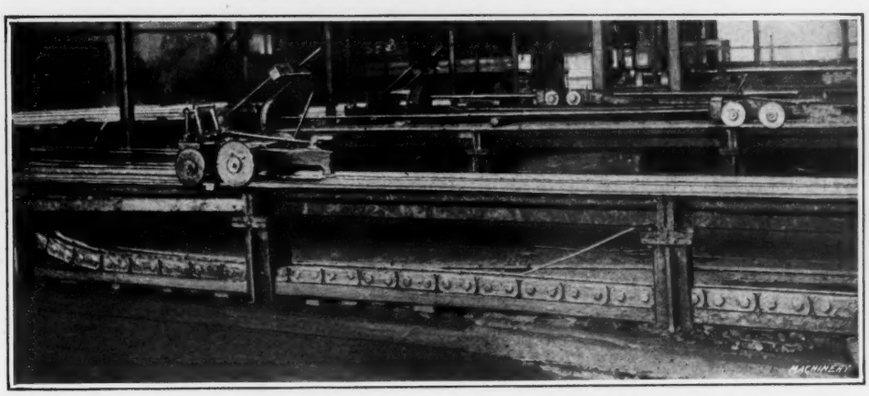


Fig. 11. Straight Draw-bench pulling Four Rods simultaneously

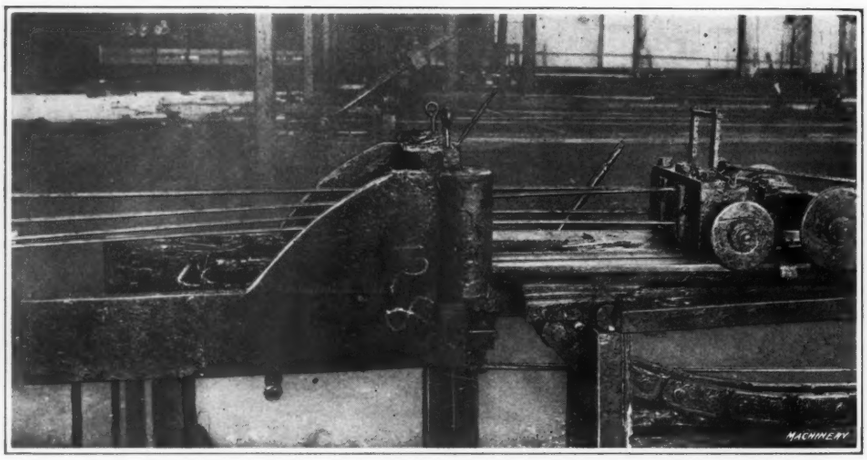


Fig. 12. Close View of Carriage and Die-head on Machine shown in Fig. 11

from 1/4 to 1 1/8 inch square or 1/2 by 1 3/4 inch flat, a drawing speed of 16 feet per minute will give satisfactory results. Reference has already been made to the amount of reduction per draw for different sizes of bars, but it will not be out of place to give some detailed information on this point at the present time. For bars up to 1/2 inch in diameter the amount of reduction at one draft is 1/32 inch; for bars from 9/16 to 3 inches in diameter the amount of reduction per draft is 1/16 inch; and for bars from 3 1/16 up to 6 inches in diameter the amount of reduction per draft is 1/8 inch. Bars over 3 inches in diameter can be most profitably finished by turning.

Power Required for Cold-drawing Operation

The amount of power required to pull a bar through the die varies considerably according to the size of the material being drawn and the nature of the steel. A general idea of the amount of power required, however, will be obtained from the following figures: In drawing four bars 5/8 inch in diameter, it has been estimated that a pull of 45 tons is required. In another plant it has been estimated that for a single bar 1 1/4 inch in diameter, a pull of 7 tons is necessary. It is the practice to hot-roll the stock which is to be cold-drawn as close as possible to the size to which the steel is to be cold-drawn. The cold reduction can then be made in one draft, using comparatively little power. On the other hand, the heavier the draft the smoother and cleaner the surface of the cold-drawn steel; but extremely heavy drafts require more power, and in the case of alloy steels or steels containing a high percentage of carbon, such heavy drafts may disturb the structure of the steel and make it unsuitable for the desired use, although a superior finish is obtained.

Fig. 13 shows a rotary type of draw-bench built by Humphrey & Sons, Joliet, Ill., and installed in the plant of the Youngstown Sheet & Tube Co., Youngstown, Ohio. The capacity is for drawing steel up to 1/2 inch in diameter. Attention is called to the fact that the first block *A* at the right-hand end of the bench is not in operation, although it is in position to be threaded up ready to start work. Just at the right of this block and projecting up through the bench there is a lever *B* which is so arranged that if a man is caught by the wire between the die and the block while feeling the wire to see if the die is working properly, his body is drawn up on the bench and strikes this lever, which automatically stops the block rotating and prevents a serious accident. Accidents of this kind are by no means uncommon among wire mill operators, and unless means are provided for stopping the machines the accident is likely to be a severe one.

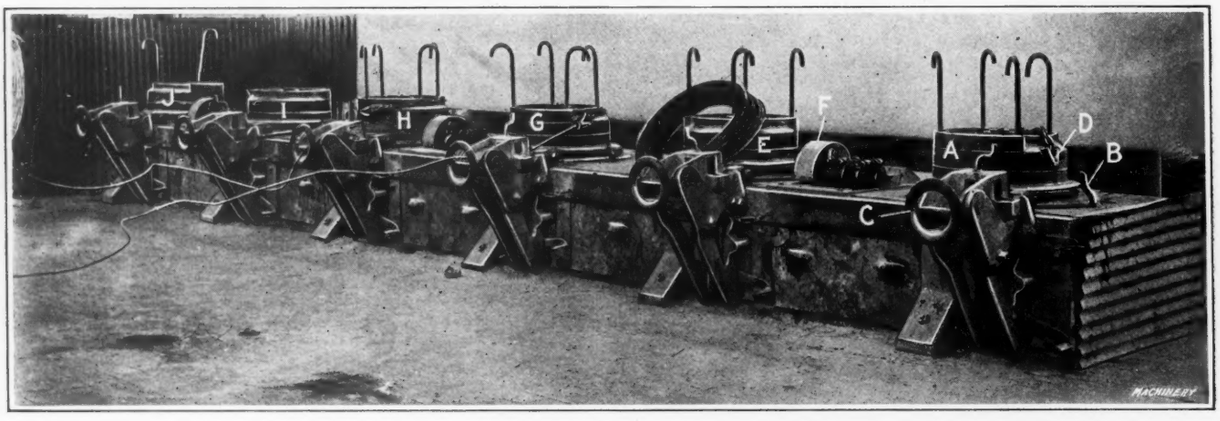


Fig. 13. Rotary Draw-bench built by Humphrey & Sons and installed at Youngstown Sheet & Tube Co.'s Plant. Attention is called to Safety Devices provided on this Equipment

At the front of the die-stand or die-holder there will be seen a guard ring *C*, which is a further device to provide for the operator's safety. In case he is caught by the wire between the reel-stand which holds the coil of steel and the

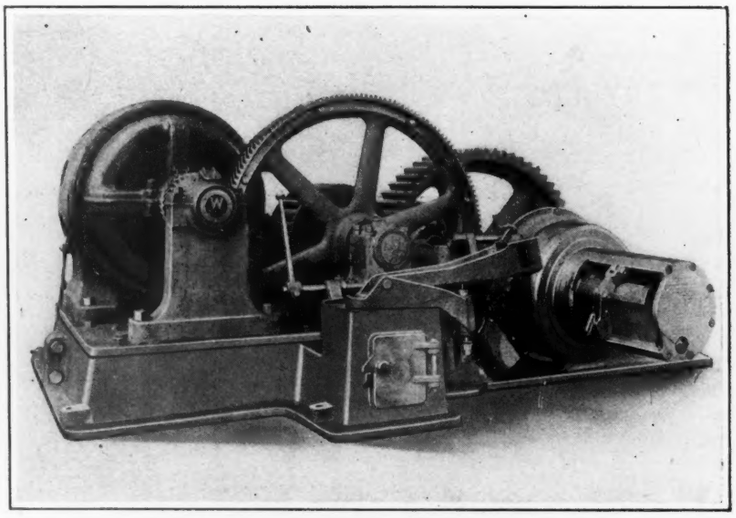


Fig. 14. Two-block Bull Frame built by Morgan Construction Co. for drawing Square, Hexagonal and Round Sections from 7/16 to 1 Inch in Size. This Machine is equipped with Westinghouse Motor

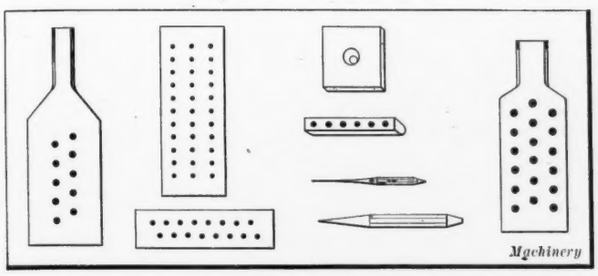


Fig. 15. Steel Die-plates for drawing Small Sizes of Wire and Screw Stock

die, his body is drawn up against this guard ring, which automatically operates an air valve that stops the bull-block from rotating. In designing these machines the effort has been made to employ safety features wherever possible, and the use of compressed air facilitates this. Where reliance is placed upon the man at the next block stopping a block after the operator has been caught by the wire, experience shows that in about ninety-nine cases out of a hundred he is too late to save the man from serious injuries. The blocks are not only air operated, but they are also furnished with individual friction drives which enable them to be stopped quickly and easily.

On top of block *A* at the right-hand side there will be seen what are known as "pullers" *D* hanging down at the side of the block. These are drawn forward with the right hand and attached to the point of the steel that projects through the die, after which the block is ready to be started rotating to draw the steel through the die and wind it up on block *A*.

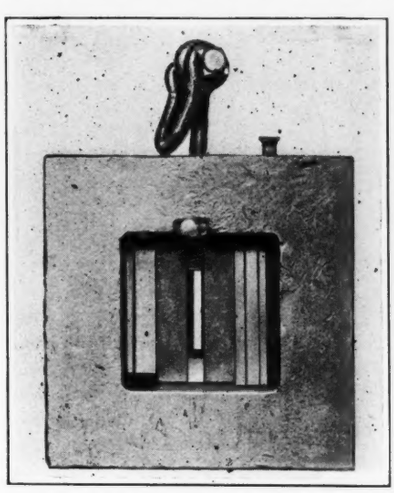


Fig. 16. "Turk's Head" or Combination Die

Between blocks *A* and *E* is a pointing machine *F*, which is used for pointing the end of a coil of steel so that it may be threaded through the die to be gripped by the pullers. This pointing machine is driven by a chain drive from the line-shaft and is of the continuous type, *i. e.*, the pointing rollers always run in the same direction instead of oscillating as they do in another type of machine for pointing stock. In the rollers there are cut grooves, the cross-section of which is gradually reduced so that as the wire is drawn through, its diameter is reduced sufficiently so that the point may be threaded through the die in the manner described.

One difference between the work done by continuous pointing rollers and rollers of the oscillating type is that with the continuous rollers a tapered point is produced, while with the oscillating type of pointer the end of the rod is merely reduced to a shoulder, which is likely to cause the point to break off instead of starting the wire through the die in the desired manner. With the tapered point it is much easier for the wire to be started through the die, and there is less strain on the die while starting to make a draft. Bull-block *E* is shown after the wire has been finally drawn through the die and the bundle has been partially stripped off the block. Block *G* has a wire threaded up through the die and the block is ready to start making the draft. Block *H* is shown engaged in the operation of drawing wire, and is partially covered with drawn wire. Blocks *I* and *J* are not shown in any special position.

After the drawing operation has been started the wire is gaged to see that it is true to size; and when the operator of the draw-bench is satisfied that this is the case, he starts the bull-block again and draws all the wire through the die. After the steel has been drawn through the die it is known as "wire," and it is ready for the market as soon as the pointed end has been cropped off and the bundle of wire has been gaged at both ends to see that the variation in size between the two ends is within the required limit of accuracy. In both cold-drawn shafting and cold-drawn wire this limit will not exceed 0.0005 inch if the work is properly done. Some variation is bound to exist due to wear of the die, and the amount of error will usually depend upon the quality of the die and the care with which the steel and die are lubricated during the drawing operation. Other factors that affect the degree of accuracy obtained are the amount of reduction required from the rod to the finished steel, quality of the steel,

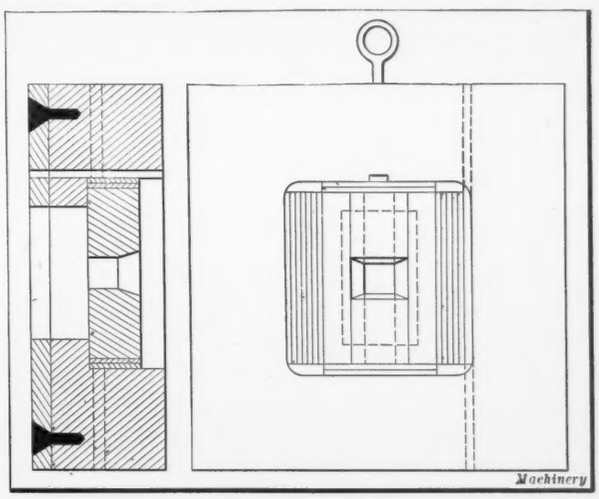


Fig. 17. Front and Cross-sectional Views of So-called "Turk's Head" or Combination Die

care taken in the pickling operation, and care taken in drying the stock after it has been immersed in the lime bath.

Types of Dies Used for Drawing Wire and Small Sizes of Screw Stock

There are two general classes of dies used for drawing screw stock. These are, first, the chilled cast-iron die, and, second, the so-called "steel die-plate." Cast-iron dies are made with one opening for drawing a specified size of steel, while in the die-plates there are a number of openings, which are used in succession until all have been worn over size. Although the method of drawing steel through these types of dies is the same, the practice in maintaining the dies in proper condition for use is quite different. In drawing steel through either type of die it will be obvious that friction gradually wears the die over size, and when the limit of over size for drawing a given diameter of steel has been reached, the methods of putting the two types of dies into condition for further use are quite different. In the case of a cast-iron die that has reached the limit of over size allowable, the

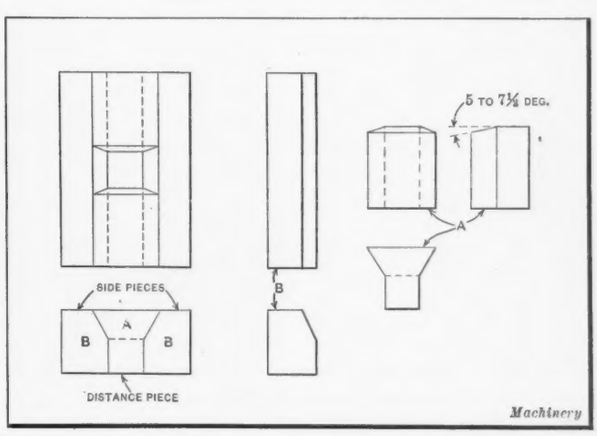


Fig. 18. Parts of Combination Die shown in Fig. 17

method of procedure is to remove the die from the draw-bench and ream out the hole to the minimum diameter allowable for drawing the next larger size of steel made in the mill where this die is used. The reaming operation is performed with a square tapered reamer, and a plug gage is used to ascertain whether the hole has been increased to the proper diameter for drawing the next larger size of steel.

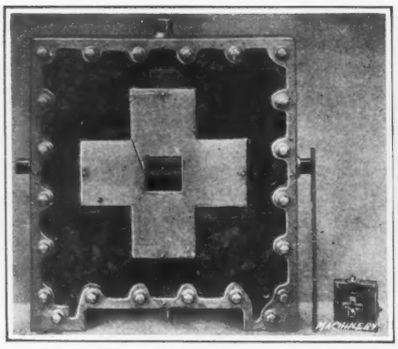


Fig. 19. Roller Die built by Standard Machinery Co. for drawing Square Bars

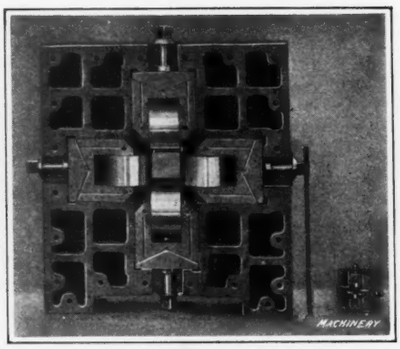


Fig. 20. Opposite Side of Roller Die shown in Fig. 19

With steel die-plates an entirely different procedure is followed. The die-plate is heated and hammered on the "leaving" or back side of the die, so that the steel is forced inward around the hole, reducing its diameter slightly more than the required amount. It then goes to a man known as a "plate setter" who uses a tapered punch which he hammers into the hole in the die while the metal is cold, thus compressing the steel around the hole and at the same time enlarging the hole to the minimum diameter which is allowed for drawing a given size of steel. From the preceding description it will be apparent that aside from the methods used for bringing the two types of dies into condition for subsequent use, there is another point of distinction, namely, that in the case of a cast-iron die the reaming operation converts this die to a size suitable for drawing the next larger diameter of steel, while in the case of the steel die-plate the hammering and punching operations simply bring all the holes in the die back into condition for drawing the same size of steel on which the die-plate was formerly engaged.

In making cast-iron dies the die opening is cast against a "chill," which results in the production of white cast iron, which is extremely hard and quite durable. Steel die-plates are sent to the steel mill with the holes in the condition known as "three-quarters pricked," which means that the holes extend only three-quarters of the way through the thickness of the die-plate. In preparing the plate for use, the holes must be pricked the rest of the way through, which is done by heating the plate and driving the punch through the remainder of the metal at the bottom of each hole. After this has been done the plate is reheated and hammered or battered around the back side of each hole—as previously explained in connection with the repairing of die-plates—after which the plate setter reduces the diameter of the holes to exactly the desired size by following the procedure described. Ten or fifteen years ago steel die-plates were used almost exclusively in this country for drawing steel wire and small sizes of screw stock, but at the present time cast-iron dies are more extensively employed for drawing round wire. For shapes other than rounds, *i. e.*, ovals, half rounds, squares, hexagons, etc., it is probable that steel die-plates will continue to be used because of the difficulty that would be experienced in maintaining cast-iron dies in suitable condition for operation. This is, of course, due to the fact that irregular shaped die openings cannot be reamed. In Europe and especially in English wire mills, steel die-plates are still generally used.

Although steel plates can be used repeatedly for drawing wire of the same sized hole, while cast-iron plates have to be reamed out for a new size of wire each time they are used, the original cost of the steel plates and the labor expense involved in setting them back for drawing the same size wire are greatly in excess of the cost of the cast-iron die and labor charge involved in reaming it out to permit a larger size wire to be drawn. Chilled cast-iron

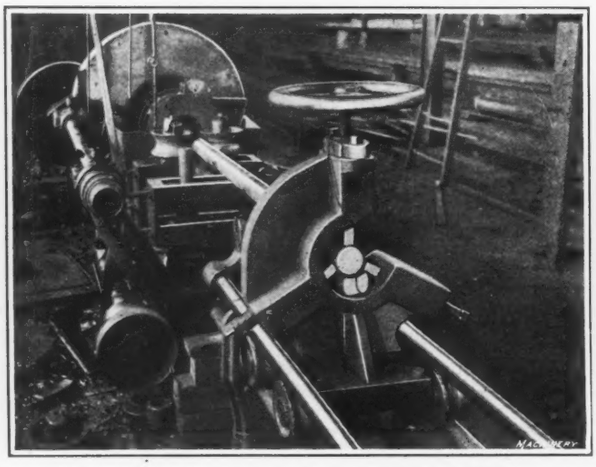


Fig. 21. Special Lathe used for turning Large Sizes of Shafting

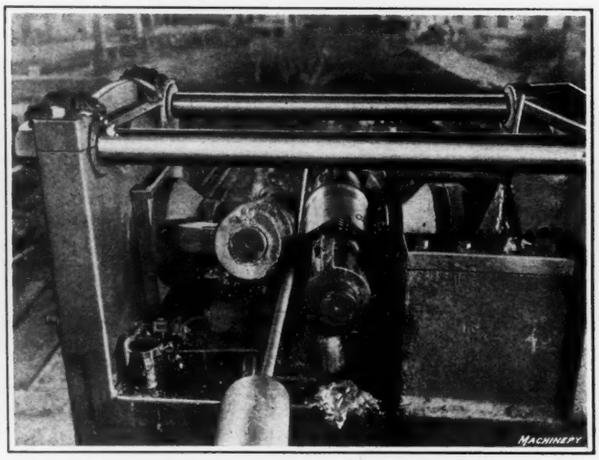


Fig. 22. Medart Shaft Straightening Machine in Operation

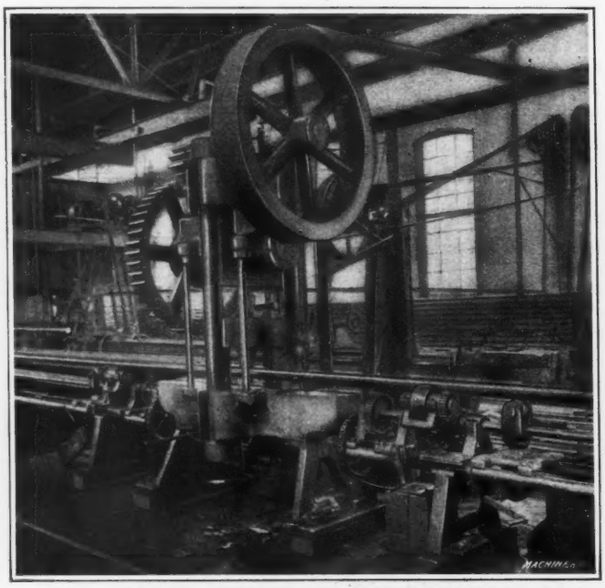


Fig. 23. Brightman Straightening Press for straightening Shafting turned on Machine shown in Fig. 21

dies and steel die-plates are usually made for drawing stock up to 1/2 inch in diameter; in some cases larger stock is drawn in these dies.

Dies for Drawing Shafting and Larger Sizes of Screw Stock

For drawing the larger sizes of screw stock and all sizes of shafting, there are several types of dies that are commonly employed. For drawing round stock the most commonly used die consists of a disk of high-speed steel — "Red Cut Superior" steel is one brand that gives satisfactory results—with a round opening which is bell-mouthed, tapering gradually down to a straight throat of the same diameter as that of the steel which it is desired to draw. For steel from 1 1/16 inch to 2 1/8 inches in diameter, the die-block is 6 inches in diameter by 1 1/2 inch thick; and for steel from 2 1/8 to 3 1/8 inches in diameter the die-block is 8 or 10 inches in diameter by 2 inches thick. For round stock the hole in the die is drilled and the required taper opening or "bell-mouth" is bored, after which the straight throat of the die is carefully reamed to size. Dies for drawing hexagon and octagon shaped bars are first drilled, after which the flat sides are worked out with a "punch bar" in the shaper, and then the die is finished to size by hand filing. The dies are heat-treated according to instructions given by makers of the particular class of steel from which they are made.

There are two types of drawing dies in general use which are known as the "hard" die and the "soft" die. As their names imply, the steel in these two types is hardened or left soft as the case may be, and each form has certain points in its favor. The hard die is made to exactly the required form and size, after which it is heated and quenched by passing a stream of cold water through the opening. This results in hardening the metal so that the die is able to draw from 500 to 1500 40-foot bars according to the nature of the steel in the bars and in the dies through which they are drawn. In soft dies, the steel is left in a soft condition and these dies have a capacity for drawing only 12 to 15 40-foot bars. At first sight, it would appear that this difference shows an overwhelming superiority in the hardened die, but this need not necessarily be the case, as the soft dies are easily put back into condition for further service. This is done by hammering the dies at the "leaving" side, which results in causing the metal to flow in and reduce the diameter of the opening, after which the hole is reamed out to exactly the required size. This work can be done with great rapidity.

In the case of the hard die it is necessary to heat it above the critical temperature and then pass a stream of cold water through the opening, which causes it to shrink sufficiently to reduce the diameter of the hole beyond the required size, after which the die is lapped out to secure the correct diameter. This is necessarily a slow and costly operation, so that, although the hard die has a far greater capacity as regards its productive life, the cost of putting it back into condition after it is worn out is much greater than in the case of the soft die. In connection with the method of reducing the hard die to size after it has been worn, it must be borne in mind that the shrinkage of the metal around the hole at the time the steel is quenched results in drawing in the plastic steel sufficiently, and as the amount of wear in any case will not exceed 0.001 inch the results obtained in this way are highly satisfactory.

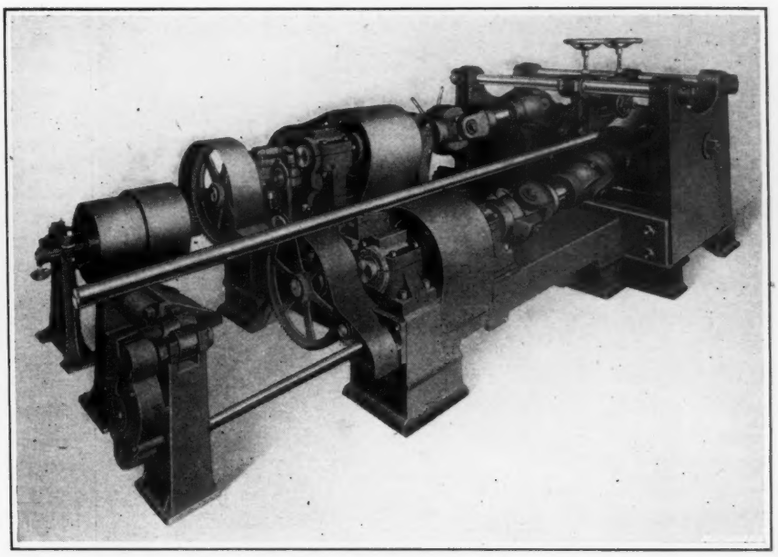


Fig. 24. Continuous Automatic Shaft Straightening Machine built by Medart Patent Pulley Co.

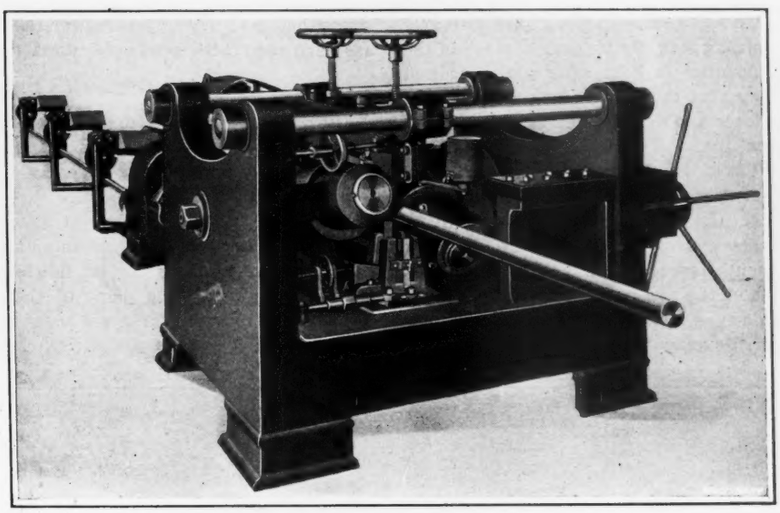


Fig. 25. Opposite Side of Medart Straightening Machine shown in Fig. 24

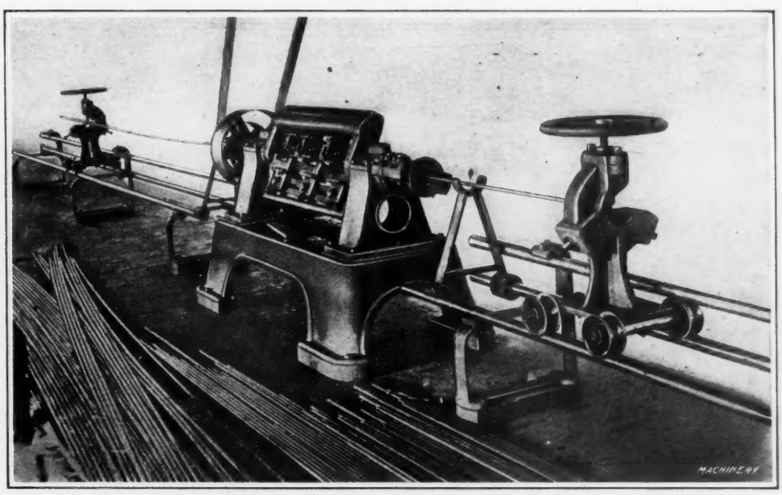


Fig. 26. Rotary Type of Shaft Straightening Machine built by Brightman Mfg. Co.

Dies for Drawing Squares, Rectangles and Other Irregular Shapes

Different methods must be followed in designing dies for drawing irregular shaped bars from those used in making dies for round stock. This necessity arises from the fact that trouble would be experienced in maintaining solid dies of these shapes in the required condition. Some dies for drawing squares, hexagons and octagons are made from solid blocks, but it is probably better practice to use either a die of the type known as a "Turk's head" or one of the special dies constructed with rollers that engage the stock to be drawn. Figs. 16, 17 and 18 show the Turk's head type of die, and Figs. 19 and 20 show one of the rolling mill type of dies.

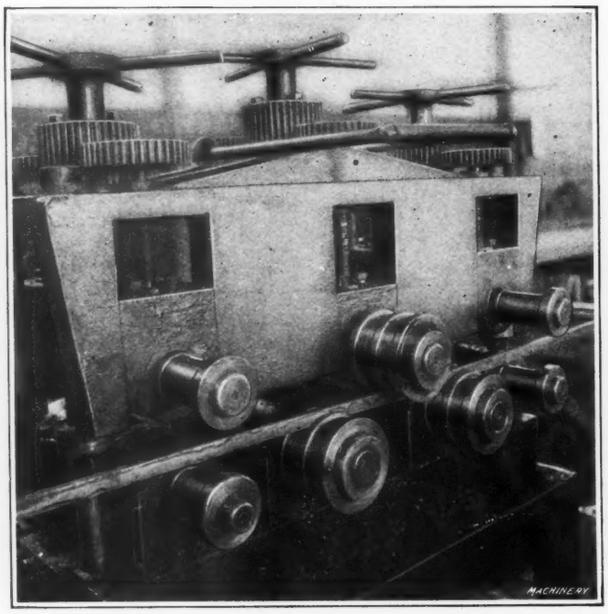


Fig. 27. Machine for straightening Square, Hexagonal, Octagonal and Flat Bars

It will be seen that the Turk's head die (Fig. 18) has a steel frame in which are supported two pieces *A*, known as "distance pieces," and two side pieces *B*, these four parts being securely wedged in place in the frame, so that the die opening is kept exactly the desired size. Compensation for wear of the die is made by adjusting the position of the side pieces and distance pieces with wedges in the die frame. From the detail views of the distance pieces and side pieces it will be seen that these parts are fitted together in such a way that the pressure applied in drawing the steel through the die cannot result in pulling either of the die members out of place. The die opening is arranged with a bell-mouth tapered from 5 to 7 1/2 degrees according to the hardness of the stock to be drawn. In addition to making dies of this type for drawing squares and rectangles, the same type of die may be employed for drawing bars with straight sides and semicircular sections at the top and bottom. For drawing hexagons and octagons, sectional dies of this type are made with the sections adjusted radially by means of screws.

In Figs. 19 and 20 are shown front and rear views of one of the rolling mill dies made by the Standard Machinery Co. of Auburn, R. I. This particular die is for drawing square-shaped stock, and it will be apparent that four hardened steel rollers are arranged to bear against the four sides of the stock and reduce it to the required diameter. Obviously the form of the rollers provides a die opening corresponding to the bell-mouth of either a solid or a "Turk's" head die. The opening in the die can be adjusted to any size within its limits without changing the rolls, by simply turning the square-headed screws provided for that purpose. These screws are furnished with graduated dials to facilitate setting.

Lubricants Used on Drawing Dies

Lubrication of the steel and drawing dies is a matter of the utmost importance. If even a small area of steel is drawn into the die without being properly coated with lubricant, it will "seize" and do much damage through scoring the surface of the die opening. A variety of different lubricants are used on drawing dies, and each manufacturer of cold-drawn screw stock and shafting has certain lubricants of which he speaks in high terms. At the plant of the Pennsylvania Shafting Co. two different mixtures are used for lubricating the dies. One of these is compounded from tallow, heavy machine oil

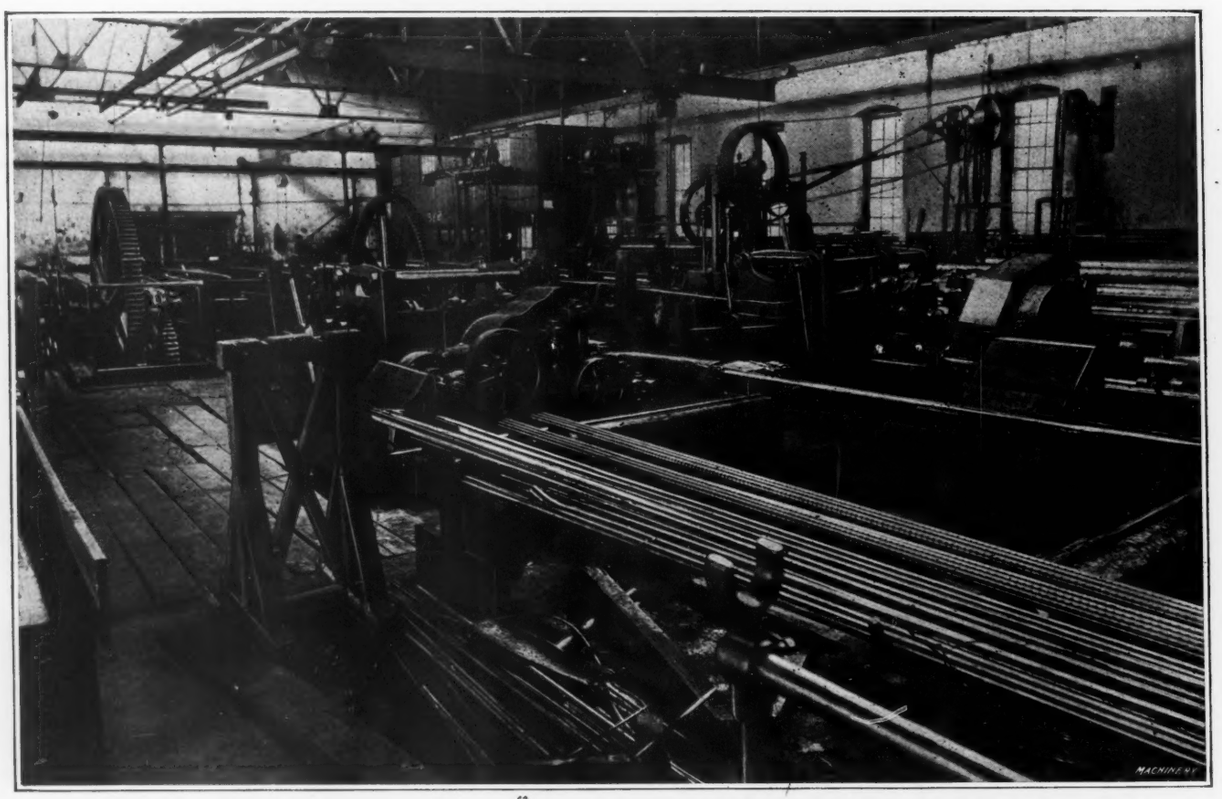


Fig. 28. General View in Mill of Pennsylvania Shafting Co., showing Part of Department in which Round Shafting is drawn

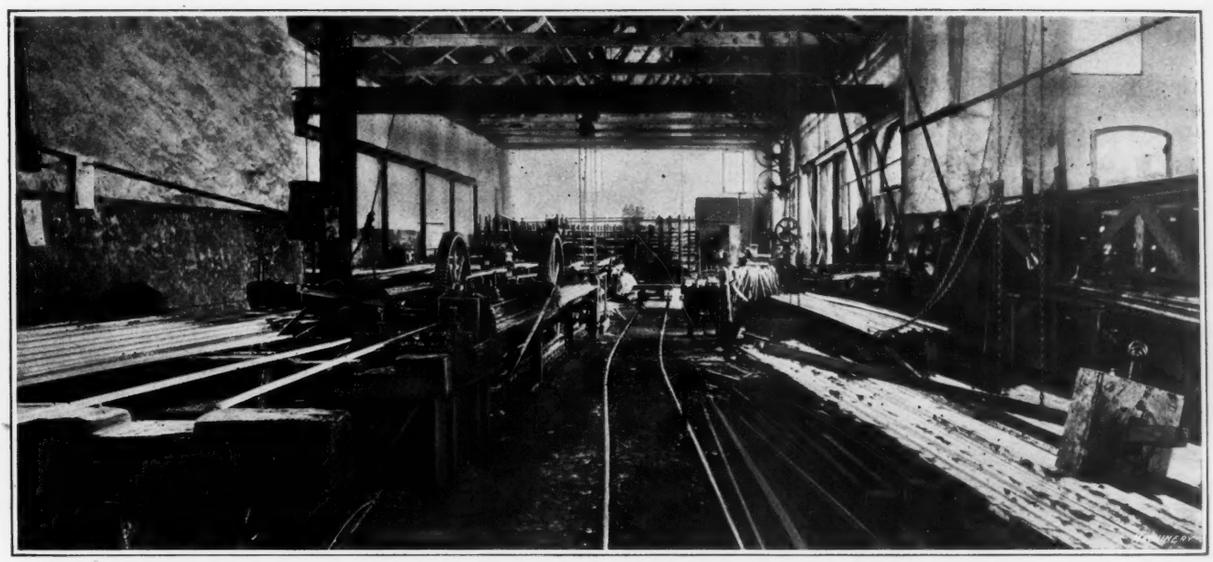


Fig. 29. General View in Mill of Pennsylvania Shafting Co., showing Department in which Square, Hexagonal, Octagonal and Flat Bars are drawn

and soap powder. These constituents are mixed in such proportions that when heated and thoroughly stirred together the resulting lubricant will be of such consistency that it can be easily rubbed onto the bars by hand as they are being drawn through the die. The other standard lubricant used by this firm is made of a mixture of cup grease, heavy machine oil and soap powder. As in the preceding case this mixture is heated and thoroughly stirred, and should be of suitable consistency to be easily rubbed onto the work.

Liquid lubricants are also used in some wire mills. An advantage resulting from their use is that means are devised for applying the lubricant to the steel bars and dies through which they are being drawn without requiring the workmen to apply grease by hand. One way is to take a large bundle of waste and soak it thoroughly in oil, after which the waste is wrapped around the steel bar and allowed to be drawn up against the die. In this way the waste is held in place against the "entering" side of the die and keeps the bar thoroughly lubricated as it is being drawn through. The selection of the proper type of lubricant is probably largely a matter of individual opinion, and the results obtained vary with the care that is taken in applying the lubricant to the work and die. Care in its application will probably have a greater effect upon the cost of lubricant used and the efficiency with which it operates than the selection of any particular type of oil or grease.

Production of Turned Shafting

It is general practice in the production of shafting to turn bars from three inches in diameter up to the largest size instead of obtaining the desired finish by the cold-drawing process. In Fig. 21 is shown a special lathe used for this purpose. It will be seen that this consists of two rotary cutter-heads, which perform rough- and finish-turning operations on the shafting. Feed is secured by means of rollers which are clamped against the work by adjusting screws. These rollers are geared to the lathe and their rotation results in feeding the shafting through the cutter-heads. As bars from thirty to forty feet in length are frequently turned on machines of this type, it is necessary to provide means for supporting the ends of the work. Such means are furnished by carriages at each side of the central part of the machine that carries the cutter-heads; these carriages run on tracks and the ends of the steel shafting are supported by them. The carriages are not geared to the machine; they simply run along the tracks as the shafting is fed through the cutter-heads, and provide the required support so that the shafting is not unduly distorted. After being turned, the shafting is straightened on the so-called "flyer" type of straightening machine shown in Fig. 26, which imparts a burnished finish to the steel in addition to straightening it ready for use. The extreme end of bars straightened in this type of machine is bent out of true alignment, and this is corrected on a punch press with a three-point support for the work, as shown in Fig. 23.

Some steel mills report that there is a decided increase in the demand for turned shafting for classes of service where cold-drawn shafting was formerly employed. Several reasons are advanced for this preference. For one thing, it is claimed that during the process of hot-rolling steel bars that are later to be cold-drawn, there is a tendency for the bars to be decarbonized at the surface. Where the cold-drawing process is employed, the scale is removed by pickling and the bars are then cold-drawn, with the result that this decarbonized surface of the steel is not removed and results in leaving a somewhat softer metal at the surface of the shafting, which is likely to cause it to wear quite rapidly. When shafting is turned, it will be obvious that this decarbonized metal is removed from the surface so that trouble of this kind cannot result. Some users of shafting also claim that during the process of cold-drawing the structure of the steel is disturbed and there are likely to be undue strains set up, which may result in trouble from breaking of the shafting. The same cause may result in trouble from automatic screw machine products made from cold-drawn screw stock, one reason being that where some sections of the stock are left the full diameter and others are turned, the internal strains may result in a tendency to spring the work out of shape. These theoretical considerations are quite interesting, although attention must be directed to the fact that they are theories and not certainties. There is a great diversity of opinion regarding the relative merits of cold-drawn and turned shafting, and many advocates of cold-drawn shafting are prepared to claim that it is a far superior product to that produced by turning.

Straightening and Cutting Up

The practice followed in straightening cold-drawn bars naturally differs according to the diameter of the bar and whether it was drawn in a straight draw-bench or a bull-block machine. In the case of shafting and bars drawn on the straight bench, the bars are passed through a straightening machine, which consists of a rotary cradle that supports staggered rolls. While the shafting is being drawn through the cradle, the latter rotates around the work, with the result that it is left in a perfectly straight condition. The rollers also impart a fairly high polish to the steel drawn through them. In the case of long coils of metal that have been drawn on a bull-block, a similar form of straightening machine is used, but, in addition, provision is made for cutting the work into pieces of standard length. For this purpose the bar is drawn through the rolls carried in the rotary cradle, and when the end has been drawn through the required distance it comes into contact with the trip or trigger on the machine, which results in actuating a shear blade that cuts off a piece of standard length. The position of this

trigger may be adjusted to provide for cutting off bars of any required length, which may be as short as two or three inches or up to practically any desired length.

Another type of machine for straightening round bars, which has been found to give very satisfactory results, is the Medart straightener built by the Medart Patent Pulley Co. of St. Louis, Mo., shown in Figs. 24 and 25. This machine has only two rollers, one of which is a straight cylinder and the other slightly concave. It will be seen that these rollers are set with their axes at a slight angle to each other and that the rollers are driven in opposite directions by means of universal joints and shafts. One end of the bar to be straightened is inserted between the rollers, and the angular position of the rollers, combined with the fact that they rotate in opposite directions, results in drawing the bar through the machine at a rate of from twenty to thirty feet per minute. A little thought will make it apparent that the action of rolling a bar between the straight and concave rollers effects practically the same result as drawing the bar through a set of staggered rollers on the type of straightening machine to which reference has just been made. The Medart straightener is adapted for handling bars up to three inches in diameter, and one feature claimed for it is that a particularly high polish is produced.

For straightening square, rectangular, hexagonal and octagonal bars, it will be obvious that a different type of straightening machine must be employed from those that have been described. The type of machine used for this purpose is shown in Fig. 27. It consists of two sets of five pairs of staggered rollers, those for straightening the bars sidewise being located between the housings of the machine, while the rollers for straightening the bars edgewise are located outside the right-hand housing, as shown in the illustration. Work is passed through the machine at a rate of about twenty-five feet per minute. The bars are given two passes through these rollers for each pair of opposite sides of the bar, *i. e.*, a square bar receives a total of four passes, while an octagon shaped bar requires eight passes to completely straighten it.

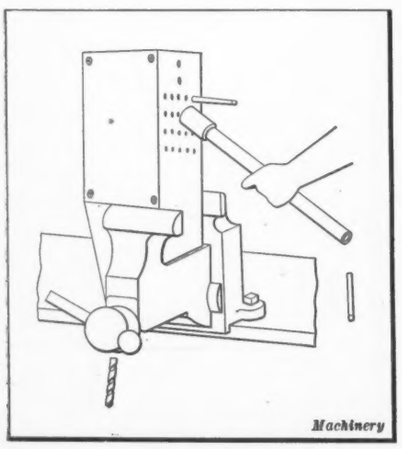
Packing and Shipping

After being straightened and polished, the steel is usually wrapped in wax paper and then in burlap, so that adequate protection is provided against rusting in transit. As one of the important advantages obtained by the cold-drawing process is that the steel is given a bright finish, it would be the height of folly to ship the metal in any way which did not afford adequate protection against oxidation. In some cases the burlap bundles of steel are packed in wooden boxes so that they are held straight, thus assuring delivery to the purchaser in the best possible condition.

* * *

AN EFFICIENT DRILL BREAKER

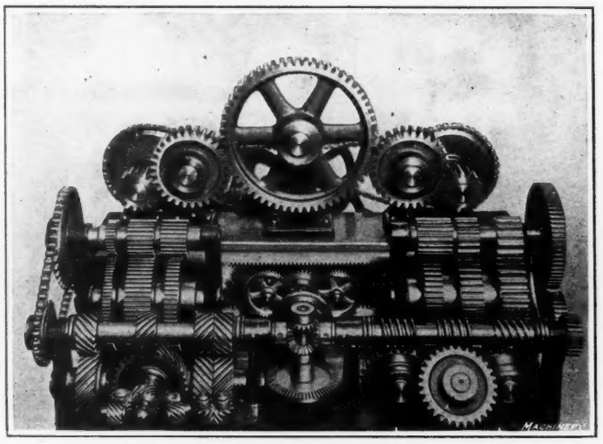
Separating the high-speed part of drills from the shank or machine steel portion is a profitable practice, for high-speed steel can be sold as scrap now at a very good price provided it is not mixed with other grades. The illustration shows a method used in the Ford plant for breaking off the drill ends that is both efficient and safe. The hard part of the drill is inserted in the holes as shown and a section of pipe is placed over the projecting shank. A slight pressure serves to break the two sections apart, the shank slipping down the handle while the other part falls into a box below the vise.



Device for separating High-speed Steel Part of Drill from Shank

STOCK GEAR EXHIBITION MACHINE

The Boston Gear Works, Norfolk Downs, Boston, Mass., have on display at the store of Patterson, Gottfried & Hunter, Inc., New York City, an exhibition machine made entirely of stock



Machine of Stock Gears made by Boston Gear Works

gears. It includes an assembly of sixty-three spur, bevel, spiral and worm gears driven by a 1/30-horsepower motor, the driving pulley being 3/4 inch in diameter, which shows that friction is comparatively negligible. A special feature is two right- and left-hand spiral gears, placed on the same shaft, driving two spirals that mesh with gears whose axes are placed at right angles; these gears, in turn, mesh with each other, thus forming a complete cycle.

* * *

PITCH, LEAD AND THREADS PER INCH

While the terms "pitch," "lead" and "number of threads per inch" as applied to screw threads are defined in nearly every machine shop handbook and text-book on shop practice, there are apparently many mechanics who do not clearly understand the distinction between the three terms. In nearly every manuscript relating to thread gages and screw threads submitted for publication, these terms are incorrectly used. The distinction between "pitch" and "lead" seems to be fairly well understood, the "pitch" being the distance from the center of one thread to the center of the adjacent thread, while the "lead" is the distance that a nut will advance on the screw if turned around one complete revolution. In single-threaded screws, of course, the pitch and lead are equal, but in multiple-threaded screws the lead is a multiple of the pitch.

The most common error, however, is that of confusing "pitch" with "number of threads per inch." If a screw has eight threads per inch, the pitch is 1/8 inch, and while the expression "8 pitch" is frequently used in the shop, it is erroneous and has become sanctioned only because mechanical writers have repeatedly made use of this faulty expression. The proper mechanical definition of pitch, according to Webster, is "distance apart of two things, especially consecutive ones in an equidistant series." To apply the term to the number of threads in a unit length is erroneous according to this definition, even though common usage and mechanical writers in general have so often misapplied the term.

The necessity for calling attention to the distinction between "pitch" and "number of threads per inch" is obvious when we consider that in formulas involving the pitch it is required to multiply by the pitch, when we divide by the number of threads per inch, and if the term "pitch" is not properly understood, a serious error would be made in the application of formulas that contain this term. As an example, a case may be referred to where a trained engineer recently changed the multiplication sign in a formula containing the term pitch to a division sign, simply because he confused the terms "pitch" and "number of threads per inch." Hence these two facts should be kept constantly in mind: Pitch is the distance in inches from thread to thread. It is always the reciprocal of the number of threads per inch—that is, if the number of threads per inch is sixteen, the pitch is 1/16 inch; if it is twelve, the pitch is 1/12 inch.

ON TESTING MATERIALS

NOTES ON THE INTERPRETATION OF RESULTS OBTAINED FROM VARIOUS TESTS

BY WILLIAM KNIGHT [1]

THE object of this article is to describe in a general way different methods of testing materials and to call attention to a few considerations bearing upon the correct interpretation of the results obtained from tests. Of all tests, that most generally adopted is the tensile test, which allows one to plot a stress-strain diagram from which the strength, elasticity and ductility of a given material can be determined. The usual criteria of the ductility of a metal are the percentage of elongation and the contraction of the cross-sectional area in a test-piece fractured by tension. Of the two, probably the percentage of elongation is the better; smaller elongation is sometimes accompanied by greater constriction of area. The per cent elongation of a test-piece originally L inches long, and L_1 inches long after fracture has taken place, is given by the following equation:

$$100 \times \frac{L_1 - L}{L} = \text{per cent elongation}$$

In stating that a given material has a certain per cent elongation, the original length of the test-piece must always be stated. The dimensions of the section of the test-piece will also influence the per cent elongation, because the local contraction of the section at points adjacent to the point where fracture occurs will extend over a longer portion of a test-piece of larger section than it will in a test-piece of smaller section, thus adding more to the per cent elongation of the thicker test-piece. From what has been said, it is evident that the adoption of an international standard for both length and section of test-pieces would be highly desirable in comparing results of tests of the same material. The German practice is to use test-pieces geometrically similar, and this is obtained by keeping the gage length of the test-pieces in constant relation to the area of the cross-section:

$$\frac{\text{Length}}{\sqrt{\text{Cross-section}}} = 11.3$$

A test-piece 8 inches long and 0.5 square inch section will meet the above specifications. This practice, however, has not been followed either in England or the United States, on account of the increase in cost of preparing the test-pieces. The British practice is to use a gage length of 8 or 10 inches, irrespective of the area of the section. The total elongation E of a test-piece of section A and length L is made up of an amount taking place all over the gaged length (and consequently proportional to it) and another amount taking place locally at the point of fracture, and proportional to the square root of the cross-section. Professor Unwin shows that for the same quality of metal the following relation exists:

$$\text{Per cent elongation} = 100\left(\frac{C\sqrt{A}}{L} + B\right)$$

For any value of A and L, C and B are two constants, and may be easily determined for a metal of a given quality by measuring the elongations of two test-pieces of any dimensions, finding the per cent elongation for both, and substituting the values in the above formula. Two simple equations will be obtained with two unknowns C and B, from which the values of C and B can be easily obtained. After calculating C and B for any particular grade of a given metal (and it is better to average the values obtained from more than two test-pieces), the per cent elongation of any other test-piece of the same material, for any value of A and L, can be predicted by substituting the calculated constants and the known dimensions of the test-piece in the preceding formula. The per cent contraction of the section, reckoned on the original area, in a test-piece of perfectly plastic material (a uniform contraction taking place all over the length), provided that the volume before and after breaking does not change, is equal to the per cent elongation reckoned on the final length at the time of measurement.

When, instead, the material does not draw uniformly throughout the length, and at the point where fracture takes place presents a neck, the per cent reduction in section at that point is greater, and this will be taken as a criterion of the maximum possible reduction in section of the material tested. When testing a material, the intensity of the stress corresponding to a given elongation of the test-piece is generally reckoned on the original area of the section. Actually, however, the intensity of the stress in the test-piece is greater than the nominal value obtained by dividing the load applied by the original area of the cross-section. This is due to the reduction of area taking place in a ductile material stressed in tension. We have seen before that, if the density of the material of the test-piece does not change during the test, the volume before and after breaking does not change. Calling L and L_1 the gaged length before and after breaking, and A and A_1 the area of the cross-section before and after breaking, we have:

$$L_1 A_1 = LA$$

from which:

$$\frac{L_1}{L} = \frac{A}{A_1}$$

This ratio of the intensity of the actual stress and the nominal stress can be expressed (calling P the applied load):

$$\frac{P \div A_1}{P \div A} = \frac{A}{A_1}$$

Hence we have:

$$\frac{\text{Intensity of actual stress}}{\text{Intensity of nominal stress}} = \frac{A}{A_1} = \frac{L_1}{L}$$

Knowing $L_1 = L +$ elongation, as obtained from test for a given load P producing a nominal stress $\frac{P}{A}$, it is easy to obtain the actual stress $= \frac{L_1}{L} \times \frac{P}{A}$. In this way it is possible to find the intensity of the actual stress in a test-piece when the reduction of area takes place nearly uniformly throughout the gaged length. When contraction begins to be prominent at one spot (where fracture finally occurs), the relation $\frac{L_1}{L} = \frac{A}{A_1}$ is not true any more, and the actual stress cannot be obtained from L and L_1 and $\frac{P}{A}$. Actual measurement of A_1 will be necessary in order to find $\frac{P}{A_1}$. We have pointed out before the influence on the per cent elongation of varying the section of the gaged length of a test-piece, and the desirability of keeping the length and the section of different test-pieces in a constant relation, in order to be able to compare the results of different tests. It remains to state the effect of reducing the length of the gaged length which is of a smaller section in the middle than at the ends of the test-piece.

A test-piece of a ductile material with a reduced section extending over a short portion, with two enlarged sections at the ends, will show in test a reduction in section and an elongation smaller than the reduction in section and the elongation measured over the same length at the center of a test-piece with a reduced section extending over a longer portion of the total length. The yield point stress and the ultimate strength, reckoned on the original area of the section, will be higher in the short test-piece than in the longer one. This is probably due to the fact that in a ductile material failure occurs by slippage along planes of shear at 45 degrees with the direction of the pull, and in a short test-piece, the proximity of the section where breakage occurs to the larger sections at the ends will offer a larger sectional area resisting shear in

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a short test-piece than in a longer one, where the section of breakage is far from the enlarged ends of the test-piece. In order to avoid misleading results of tests, due to the influence of the enlarged sections at the ends, the length of the reduced section in the middle should not be less than nine times the diameter, and the gaged length at least eight times.

Sharp angles and abrupt changes of sections in test-pieces must be carefully avoided, their influence being to lower the nominal ultimate strength of the test-piece. This is particularly true for brittle materials like cast iron and hard steel. Tensile tests are the most common and the most practical tests to which metals are ordinarily submitted in order to gain some knowledge of their physical properties. Other mechanical tests—compressive, shearing, bending, torsional—either applied gradually or suddenly, and work-shop tests—bending double, bending single, hammering down, punching, etc.—are sometimes used for measuring the resistance of materials to various forms of stress. Tensile tests, however, are the ones that yield the most useful information regarding the behavior of metals. The necessity of using for tests of this nature accurate and very costly machines, of taking rather large test-pieces from the materials to be tested, of subjecting these test-pieces to most careful and therefore somewhat expensive preliminary treatment, and of entrusting the tests themselves to an expert staff, renders the expense and the time required for such tests relatively large.

Many inventors have sought to supersede them by more rapid and cheaper methods, even at the expense of sacrificing some degree of accuracy. Among such methods may be mentioned the hardness test. In 1900 Brinell suggested the use of a very hard steel ball pressed against a surface of the metal to be tested, and measuring the area of the depression produced on that surface. If a ball of constant diameter is used (generally 10 millimeters), and a constant pressure is applied (generally 3000 kilograms for iron and steel), the hardness of different specimens of the same material tested will be inversely proportional to the surface of the depression produced. The ratio $\frac{\text{pressure}}{\text{surface of depression}}$ is called the "coefficient of hardness," or "hardness number." By comparing the results of numerous tensile tests on steel with the hardness numbers obtained from the test-pieces used, Brinell concluded that a definite relation exists between the ultimate strength and the hardness number, and that, by multiplying the hardness number by various coefficients, according to the grade of steel tested, and according to the impression made in the direction of rolling or across the grain, in case of rolled materials, the ultimate strength could be predicted very closely.

The importance of this process is readily understood, and the possibility of making a Brinell test on finished parts without injuring them offers a decided advantage over the tensile test, if only the ultimate strength of the material is to be investigated. Unfortunately, other experimenters, such as Mr. Breuil, have found that this method may result in erroneous results. At the Copenhagen Congress of the International Society for Testing Materials, Mr. Ludwik, of Vienna, who had been deputed to report on hardness tests, concluded, on the evidence of all the previously published data, that no simple relation existed between the elastic limit, the breaking stress and the hardness number, but that this did not exclude the possibility of deducting the elastic limit and the ultimate stress from hardness tests, by means of certain empirical coefficients. By determining the coefficient for each group of sufficiently similar materials, a fairly satisfactory approximation can be arrived at. Mr. Ludwik further notes that for a metal that displays constriction, the breaking strain does not yield an exact idea of the specific strength. The Copenhagen Congress came to no decision as to ball tests.

Other methods less frequently employed, but by no means devoid of interest, are frequently used instead of the Brinell method. We may specifically refer to the scleroscope method described by Shore and Breuil, which consists in measuring the height to which a steel ball, falling through a given distance onto the surface of the metal tested, rebounds; and Martel's method, which consists in measuring the volume of the impression produced by a pyramidal point falling from a certain height; and, finally, the sclerometers, which measure the depth of a scratch produced by a steel point loaded with a predetermined weight. Of all tests, however, the most conclusive for obtaining accurate data on the strength of a structure is that which consists in subjecting the structure itself to the maximum effort that it is designed to withstand, or even to a greater one, insuring in this way a factor of safety in the construction. Several methods have been devised for measuring the deformation of structures when subjected to a given load, and reference should be made to those of James Howard, which have been adopted by the Bureau of Standards in Washington and were made in September, 1912. Mr. Howard's apparatus consists of telescopic calipers, furnished with points beveled to an angle of 55 degrees, which can fit into cavities tapering at an angle of 65 degrees in the pieces undergoing test. Mr. Howard has used this apparatus to investigate the deformation and stresses in the elements of bridges, flood-gates, skyscrapers, steam boilers, etc.

Before concluding these notes on different methods of testing materials, it is well to mention the thermal methods of measuring stresses which in the last few years have attracted the attention of many experimenters. The determination of the elastic limit by means of a thermo-couple has been undertaken by several investigators. Magnus was the first one to point out that changes in stresses were accompanied by slight changes of temperature. Below the elastic limit a metallic bar absorbs heat when subject to tension, while above the elastic limit, due to friction of the particles gliding over each other, heat is generated in the bar. It has been stated that the thermal limit of proportionality is slightly lower than the true elastic limit and that below the thermal limit the variation of the temperature is directly proportional to the effort. Lord Kelvin was the first one to deduce the following connection between the change of temperature and the change of stress:

$$\delta T = -\frac{TA}{JSD} \times \delta P$$

where δT = change in temperature corresponding to change of stress;
δP = change of stress;
T = absolute temperature of specimen;
A = coefficient of expansion by heat;
J = Jule's equivalent;
S = specific heat of material under constant pressure;
D = density of material.

In the case of steel, taking the density as 7.5, the specific heat as 0.11 and $A = 1.2 \times 10^{-5}$ we have:

$$\delta T = 0.000012\,\delta P$$

The following will better illustrate the application of the above formula:

Stress in Pounds per Square Inch	Temp., Deg. C., Tension	Temp., Deg. C., Compression
0	20.00	20.00
10,000	19.88	20.12
20,000	19.76	20.24
30,000	19.64	20.36

It will be noted that during compression, up to the elastic limit, the phenomenon is the reverse of that observed when the material is subject to tension; instead of a drop in temperature, an increase in temperature of an equal amount is observed. Kelvin's law was tested by Jule and was found to be true for a considerable number of materials. Prof. Coker also made a number of verifications of the above law, and an interesting feature of his experiments was that he did not find any variation of temperature in specimens subject to shearing stresses. On the other hand, if a specimen was simultaneously subjected to two tensions at right angles to each other, the temperature change was found to be the sum of that due to each one acting separately. When we consider that every shearing force can be replaced by a tension and a compression, we can easily explain the reason why no indication of shearing stress can be obtained by the use of thermal methods. The maximum shear theory will explain the results

of experiments made on a specimen subjected to two tensions at right angles.

With the object of applying the phenomenon of temperature changes produced by variation of stresses as a method of determining the elastic limit of small and other samples which do not permit of the application of the ordinary methods, J. R. Lawson and J. A. Copp (see *Revue de Métallurgie*, January, 1913) have tested several steels, cast iron and various copper alloys. Tests were made in an ordinary tensile testing machine, the stretch being observed by an extensometer and the temperature variation measured by means of a copper-constantan couple, pressed into contact with the specimen by a rubber band and connected to a sensitive galvanometer. Examination of the large number of curves reproduced shows that in every case there is a discontinuity in the temperature curve in the region of the yield point, but that, generally speaking, the thermal limit is somewhat higher than the true yield point. Below the yield point some of the thermal curves are inexplicably irregular, but in no case are they represented by straight lines.

* * *

SIMPLE RELIEVING ATTACHMENT

All manufacturers know that a good lathe equipped for relieving the teeth of milling cutters, hobs, taps, etc., is an expensive tool, and unless the amount of work to be done is sufficient to yield a fair return on the investment, it would not be wise to buy an equipment of this type. In the shops of the T. C. M. Mfg. Co., Hunterton and First Sts., Harrison, N. J., the need arose for a machine for backing off the teeth of thread milling cutters. Only a moderate amount of such work had to be done, and before investing in a new relieving lathe it was decided to attempt to build an attachment for one of the machines in the shop. A very simple type of equipment was designed, and it has given such satisfactory results that the idea of purchasing a regular relieving lathe has been given up.

Fig. 1 shows the head end of a lathe equipped with this attachment, and a close view of the mechanism is shown in Fig. 2. The cutter to be relieved is mounted on centers in the usual way, and the cross-feed mechanism is disengaged from the slide so that the latter is free to be moved by a link *A*, which makes connection between the cross-slide and a shaft *B* carried in brackets at the back of the lathe bed. An oscillating motion is imparted to this shaft by means of an arm *C*, which is actuated by cam *D*, secured to the lathe spindle.

In designing a relieving attachment of this kind it was obviously necessary to provide means for handling cutters of

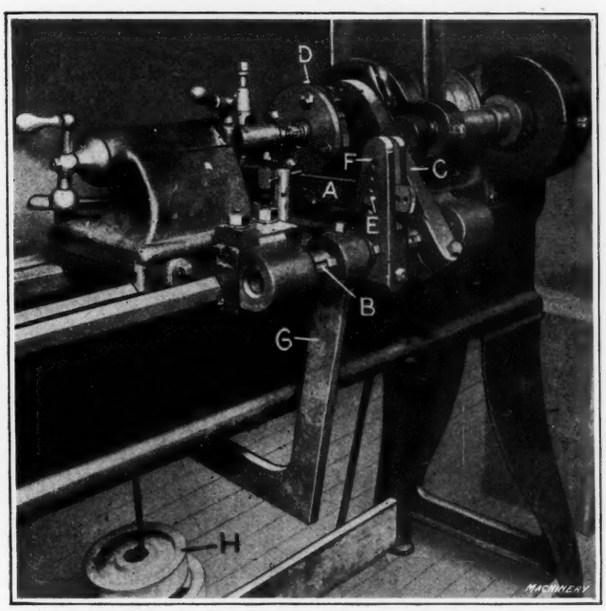

Fig. 1. Head End of Lathe equipped with Simple Relieving Attachment

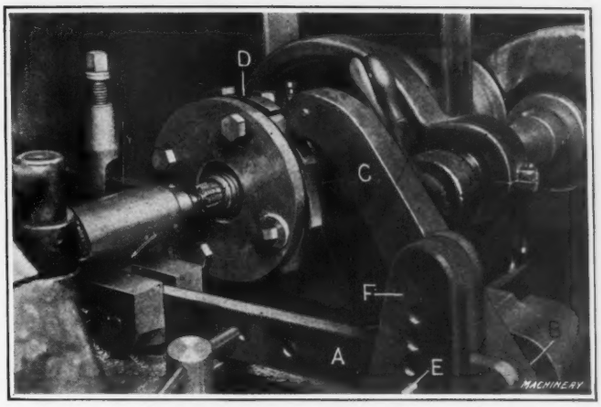

Fig. 2. Close View of Relieving Attachment shown in Fig. 1

different diameters and also for obtaining the desired amount of relief on a given size cutter. To provide for handling cutters of different sizes it will be seen that holes are drilled at various points along link *A*, and in this way the link can be slipped through the slot in link *F* so that pin *E* may be pushed into the proper hole to locate the cross-slide in the desired position for a given size of cutter. Similarly, to furnish means of obtaining the desired amount of relief on a cutter, it will be seen that a number of holes are drilled in link *F*. Link *A* can be connected by pin *E* to any of these holes in order to vary the effective radius of link *F*. In this way the desired amount of relief is obtained on the cutter. It will, of course, be apparent that bellcrank *G* and weights *H* provide for taking up lost motion in the mechanism and keeping arm *C* constantly in contact with cam *D* on the spindle of the lathe.

E. K. H.

* * *

EFFECT OF HEAT ON STRENGTH OF WROUGHT IRON[1]

For metals at ordinary temperatures the use of a proper factor of safety brings the stress for which the piece is designed well within the elastic limit. But results of tests indicate that at higher temperatures this design factor will need to be greatly modified or the work will have to be designed wholly on the basis of the elastic limit. Temperatures of superheated steam vary from 450 to 550 degrees, and the strength of tubes, valve stems, etc., as affected by these temperatures is worthy of consideration. Other examples of the same condition are encountered in boiler construction, the metal rigging above large crucibles, and ladles carrying molten metal, etc.

In a series of tests with wrought iron it was found that the physical properties are materially affected by high temperatures. The ultimate tensile strength increases as the temperature increases from 70 degrees F. until a maximum is reached between 350 and 550 degrees F., while the tenacity diminishes rapidly with the increase in temperature. The elastic limit appears to decrease from 70 degrees F. to about 270 degrees F., showing a maximum decrease of about 13 per cent, and from that temperature suddenly increases to about 350 degrees and then gradually drops. In reference to elongation under stress, it is noticed that greater rigidity exists under certain stresses at intermediate temperatures than at either higher or lower temperatures. The contraction of area at the place of rupture varies with the temperature of the bar, and it appears that the contraction of area of wrought-iron bars is a great deal less between 200 and 600 degrees F. than at 70 degrees F., and within this range of temperature there is a tendency to fracture obliquely across the bar. The results obtained for the modulus of elasticity have little value, except that they indicate a gradual decrease. The metal is very brittle between 150 degrees F. and about 1100 degrees F., and, of course, it is impracticable to work it at these temperatures, as it might fracture without warning.

[1]Abstract of an article published in "Metallurgical and Chemical Engineering," September, 1917.

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We solicit contributions from practical men on subjects pertaining to machine shop practice and machine design. All contributed matter published exclusively in MACHINERY is paid for at our regular space rates unless other terms are agreed on.

THE TECHNOLOGY OF MANUFACTURE

The manufacture of metal goods comprises a great variety of processes, many of which are quite special, limited in their application and suitable only for a comparatively narrow range of products. The common machine shop operations are turning, planing, milling, grinding, drilling, threading, tapping, reaming, chipping, filing and punching. These are fundamental processes and are well-nigh of universal application to cold metals. Common hot processes are forging, welding, rolling, brazing, soldering, melting and casting. These also are fundamental and universally employed. The specialized processes of manufacture include die-casting, extrusion, sheet metal press forming, spinning, gas and electric welding and cutting, cold-rolling, wire drawing and cold-drawing. The technology of manufacture is vast, and its development so rapid that the published record is never abreast, but, strangely, some of the developments that were practically perfected years ago have never been completely described. An example is the cold-drawing of shafting and shapes. Cold-drawn rounds, flats and squares are among the most useful forms in which steel is marketed today. The article in another part of this number, "Making Cold-drawn Shafting," illustrates and describes dies, draw-benches and practice that is being followed substantially by several well-known producers of cold-drawn products. The article should be valuable to machinists who for years have used cold-drawn products, but have never had an opportunity to see how they are made.

* * *

DEFECTS IN THE MANUFACTURE OF WAR MATERIALS

In going about the country the engineering observer cannot fail to note the enormous waste involved in the methods pursued by the government in the manufacture of war materials. It appears, to the casual observer at least, that the Ordnance Departments at Washington lack competent engineering advice; or, when such advice is freely given, are incapable of appreciating its value and thereby saving enormous sums now wasted by methods of manufacturing munitions and other war materials that no private corporations would countenance. We make this statement in order to call the attention of the Ordnance Departments to the fact that engineers throughout the country do not approve of their peculiar methods; and we do not base the statement on general observation but upon specific facts. We can point to instances where the government has engaged and maintains men as inspectors who, by ordinary engineering standards, are utterly incompetent for the purpose. We can point to a specific case where the officers of the Ordnance Departments were offered without cost, the use of a method for manufacturing certain parts in connection with rifle-making that expert engineers believed would save at least 50 and possibly 75 per cent of the present cost of manufacture; but the officer in charge refused to investigate thoroughly or test the method.

We can point to a case where identical war material is manufactured in seven different plants, each of which is required to make a complete set of jigs and fixtures at the cost of many hundred thousands of dollars, and a considerable delay in deliveries. The wise policy from an engineering point of view, would have been to distribute the contract in question between the same seven firms, but to have required each firm to make certain parts only, which could then have been assembled at one plant. By this method, one set of tools would have been sufficient, and as all the shops could have worked on subdivisions of the total contract, the time for the completion of the whole would have been considerably reduced. We can point to a case where four inspectors were employed for several weeks at a plant where there was not enough work to keep one inspector busy. We can point to cases where the designs furnished by the Ordnance Departments required finish to 0.001 inch on parts that are used only for clamping purposes, and where a finish of this degree is entirely unnecessary and involves only useless expenditure.

These are only the instances that have come under our personal observation. It is likely that others occur in many other shops. It is the duty of an engineering journal like MACHINERY to call attention to any waste connected with engineering work, particularly when this waste concerns us all and has to be sustained by the enormous taxes necessary on account of the war. The Ordnance Departments at Washington should avail themselves of competent engineering assistance when qualified engineering talent is apparently lacking within the Army and Navy organizations themselves. Officers high in rank should not ignore the help they could obtain from men who are in close contact with the industries of the country, and particularly with the machine industries engaged in interchangeable manufacture.

* * *

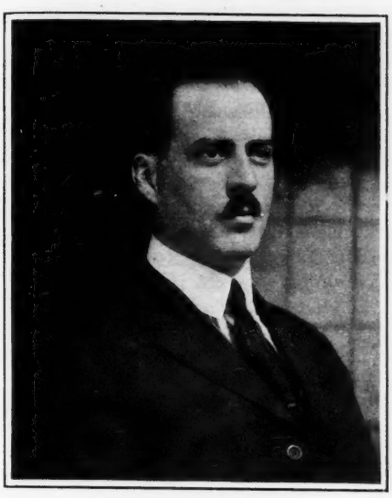
THE END OF WAR?

The placing of United States Government contracts for building 20,000 airplanes to be used by the American army in France, directs attention to the progress that has been made in aviation during the past three years. The stage has now been reached where the heavier-than-air flying machine is capable of long flights at great heights and tremendous speed. Further developments undoubtedly will make the airplane a still more formidable arm for offensive warfare. It will be possible with a fleet of airplanes to invade an enemy country no matter how strongly fortified its frontier. It is hazardous to predict the end of war, but many see that end in the ultimate development of the airplane, which will involve a complete and radical change in the settlement of international differences. No nation can afford to take the risk of being invaded by a fleet of airplanes and having its principal cities destroyed in a night.

Machine guns, heavy howitzers, high-explosive shells, the armored tanks and airplanes, all the product of the fertile mind of the engineer, have made the modern battlefield a veritable hell of destruction. The logical outcome of future mechanical engineering development is to render warfare impracticable. This war, begun for conquest with the expectation of loot, has proved a failure. If war is made not only terrible but unprofitable, it is not unreasonable to expect that future differences will be adjusted by arbitration, and understandings reached in conference by business men rather than diplomats.

A JONES & LAMSON MAN IN RUSSIA DURING THE REVOLUTION

BY GEORGE H. BRIGHAM[1]



George H. Brigham

CONDITIONS in Russia last year, when I began arrangements to leave Paris for that country, were very different from what they were when I arrived. It took me some time to get everything in connection with my work in France in good shape, so that it was December 2 before I left Paris for Petrograd. Bergen, Christiania and Stockholm were full of tourists and business men of all kinds. I arrived at Haparanda and Tornea, which are, respectively, on the Swedish and Russian sides of the line, on an arm of the Gulf of Bothnia, on December 14, and the temperature was moderate; but a few days later winter arrived, the mercury dropped to 60 degrees below and stayed there quite a time. Those cities are only a few miles from the Arctic circle, and it was hardly daylight at 9 A. M. and dark again by 3.30 P.M. The Russian winters are, after all, not much more severe than ours in Vermont. For a few days the mercury dropped to 35 or 40 degrees below, but the average was 0 to 10 or 15 degrees below. They have, perhaps, a steadier cold than we have; but in Petrograd, where there is considerable dampness, zero weather is much more uncomfortable than 15 degrees below in Vermont. The Russians wear all their heavy clothes outside, because the houses are kept so warm that heavy underwear is unbearable.

Soon after I arrived in Petrograd that infamous self-styled monk, Rasputin, was murdered, and that was really the start of the revolution. About the middle of January I left Petrograd, going to Moscow, Briansk, Kiev, Taganrog, Nijni-Novgorod, and other towns; and on this trip had some experience in wartime railroad accommodations. Sometimes I got comfortable accommodations at night, and other times I had to pass the entire night in the corridor of the sleeping car, sitting on a suitcase, jammed in a crowd of Russians and others. The hotels were always crammed full, and it was often necessary to spend an hour or two hunting for a room, which sometimes I didn't succeed in finding. In Petrograd I slept two nights on a couch in the room of another American, and in Moscow I spent three nights in a bath-room, with a resulting attack of tonsilitis. In Taganrog, a city of 75,000 inhabitants on the Azoff Sea, I stayed at what was supposed to be the best hotel in town, which sported electric lights but lacked even one sheet on the bed. Most Russians carry their own bedding, but not having acquired that habit, I had to use my fur coat to sleep in. During my second trip to Moscow we began to hear of riots in Petrograd; and as the situation grew worse, exaggerated reports of the number killed were circulated. It was only after the second or third day of the revolution in Petrograd that we saw anything of it in Moscow. First the electric cars stopped, then the cabs, and then all public and private conveyances disappeared. Crowds began to collect and discuss the situation, a condition so contrary to the old regulations that one unconsciously looked to see why the police didn't break up the gatherings. Then it was discovered that the police, too, had disappeared, having learned that nearly all their comrades in Petrograd had been killed or made prisoners. About noon on the second day of the revolution the red flag appeared in Moscow, and then all but the active manifestants disappeared as if by magic and were not seen again until it had become evident that there would be no resistance.

As soon as things quieted down a little I decided to return to Petrograd to get my passport put in order so that I might leave Russia, which I succeeded in doing after a good deal of hard work. In Petrograd everything was in chaos; every hotel was guarded by soldiers, each of whom wore a red ribbon, and thousands more were parading the streets with their red banners proclaiming the freedom of Russia. At one time there were 60,000 deserters in Petrograd alone. The casualties among the officers of the army and navy during the revolution were very heavy, but it was said that many of them got no more than they deserved, as the average Russian officer treated his soldiers like dogs. At Helsingfors and Kronstadt, the headquarters of the Baltic Sea fleet, 250 naval officers were killed, including the admiral and rear-admiral. Some statements of excesses committed by the revolutionists that have been published here may have sounded like exaggerations, but I know that at Kronstadt the admiral in charge of the Baltic fleet was arrested in his office, both arms and legs were broken, and he was then taken out on the ice, where a hole was cut, a rope was tied around him, and he was lowered into the water till he was unconscious, after which he was brought back to the surface, fed brandy until he revived, and lowered again; this was continued until he was dead beyond recall. Other examples of a similar kind could be given if space were available. Practically no work was done anywhere for about a month after the revolution began; then in many factories the workmen turned out the foremen and entire management, seized the factory and tried to run it themselves. Every prison in the country was broken open and criminal and political prisoners alike turned loose. The first of May was declared a general holiday and was the most thorough one I ever saw. No one was allowed to work. There were no electric cars, no cabs, no autos, either public or private. All restaurants were closed, and in hotels all there was to eat was cold food ordered the night before and left in the rooms. Bread had practically disappeared several weeks before, and in all Petrograd no one expected to work, because it was supposed that everybody would go back to work the next day and settle down to carrying on the war and fulfilling their pledges to the Allies.

Unfortunately, about this time Lenine returned to Petrograd, having come through Germany from Switzerland, and installed himself in a palace, as you have doubtless read in the papers. He immediately started a propaganda for seizing the property of all the nobles and rich land owners, and dividing it among the people, and favoring a pro-German peace. There was someone speaking from the balcony of his palace from morning until late in the evening, and in a short time he had the provisional government in a difficult position. It was dangerous to allow him to continue and equally dangerous to arrest him. Finally, as you know, they took steps to arrest him and he disappeared.

About 50 per cent of all munitions manufactured in Russia were made in the Petrograd district—in the city and suburbs. As elsewhere in Europe, a great many women and unskilled labor were employed, the work being split up into single operations and done on simple machines. Automatics were used to some extent, but the Russian steel bars are so irregular that they must be drawn before they can be used in automatics; consequently many shops cut up the bars and did the work on engine lathes that should have been done on bar machines. As far as possible, imported steel bars were used on the automatics, but the supply was always uncertain. Workmen and women were making quite good wages at piece rates. The best factories had all been built by German engineers and were quite well lighted and often overheated.

Before the revolution the men were working ten, twelve and sometimes fourteen hours a day, but afterward, when they

[1]Address: Jones & Lamson Machine Co., Springfield, Vt.

finally began to think of going to work, in some places they seized the factories, turning out the foremen and directors; and when that was not done, or where it was done and proved to be a failure, they struck for an eight-hour day and 15 per cent to 40 per cent increase in wages. A month later they struck again, that time for a six-hour day and a wage increase from 40 per cent to 220 per cent. Machine tools from all countries could be seen in the factories, but they were largely American, German and Swedish. A great many American machine tools built by irresponsible firms were practically a dead loss. Some tools were built by concerns that evidently knew no more about building machine tools than they did about manufacturing watches. The ———— was one. I saw twenty machine tools in one shop, not one of which would work to within 0.020 inch, and they were continually breaking. Even engine lathes had to be rebuilt. The reliable American manufacturers were sending a good class of machines, but were so far behind in their deliveries that the Russians took others on which they could get prompt delivery. It is a safe guess that some of these newly formed American machine companies will do no more business with Russian concerns.

Before the revolution arrangements were being made to turn out large quantities of munitions in Russia. A combination of capitalists and bankers had established a factory known as the Lisvensky Zavod (Lisvensky shop) at Lisva, about fifty miles southeast of Perm in the Urals, where munition work is now being done. A big factory for munitions was being built at Kharkoff in the southeast of European Russia; another at Rostoff-on-the-Don, at the mouth of the river Don where it flows into the Azoff Sea. The Russo-Baltic Mechanical & Shipbuilding Co., whose main works are at Revel, on the Baltic, have built a factory at Taganrog, on the Azoff Sea. The works of the International Harvester Corporation at Lubertsy, near Moscow, were running about 5000 men and they had bought a neighboring plant. Various manufacturing enterprises were being developed in other parts of Russia, nearer the sources of supply for raw material, in the Urals and in the south; and if they ever get settled down to a stable form of government with an intelligent policy for helping the development of the country, there is almost no limit to the business that we can do over there. It is possible when that time comes the average Russian will have become honest enough so that business can be done without paying out so many bribes. Men selling machines there told me that unless they sold to personal friends, they had to count on about 25 per cent of the selling price for graft to foremen and others.

I had my ticket on the Trans-Siberian express for about two weeks, and when I left, all tickets for that train had been sold out for at least two months in advance. There is but one through train a week to Vladivostock on which berths can be reserved and which carries dining-cars. I was mighty glad to get away from Petrograd, especially as at every stop there was an argument with soldiers and deserters who insisted on getting into the train and filling up the corridors; but the porters, knowing that the tips at the end of the line depended on their passengers getting through, kept the doors locked and informed the soldiers that there was an American and Japanese mission on board hurrying back to their countries to get aid for New Russia, and that statement helped us to get through. We finally arrived at Vladivostock twenty-five hours late, after ten days of continuous traveling in the same train, the longest train ride without change in the world. We were relieved on arriving to find there had been no change in the government since we left Petrograd, so that our passports, as viséd before leaving the capital were still valid for leaving Russia. There were various regulations in regard to what one could take out of the country—five hundred rubles being the limit for money—but when I came to pass out no one asked me about money at all, as everything was in a complete state of disorganization.

Japan was a wonderful contrast to Russia, the officers were alert and courteous and the baggage was soon examined. Everywhere we saw evidence of organization, energy and activity, and could readily understand the reason for the outcome of the Russo-Japanese war. In my travels around Japan visiting factories and dock yards I was surprised to see how modern and up-to-date their equipments were. Nowhere did I see any hostility to the United States. On the contrary, the Japanese have such a good opinion of us that in the development of their country they are using almost entirely American methods. Their train service is excellent, their roadbeds are rock-ballasted and dustless, most of the locomotives are American, and their express trains compare favorably with ours.

You ask me what is the machine tool future of Russia? If you will tell me the political future, I will try to guess at the other. If the radical socialists and anarchists get the upper hand, as I am afraid they will, the future will be dark in every way. Everyone knows that there are limitless possibilities in Russia, but many Russians returning from America organized anti-American demonstrations, saying that America is not a country of freedom, for everyone has to work!

* * *

STANDARD ARMY TRUCK

October saw the completion of the first Class B standard army truck, which is a combination of the best features of various motor trucks and those features that military experience has shown desirable; it is thought to be far in advance of anything yet produced. Although in outward design it represents no radical departure from the usual army motor truck, every part has been so standardized that all parts are interchangeable, which is expected to give added efficiency at the front. It has a two-wheel drive and is able to make twelve or fourteen miles an hour. The engine weighs 1012 pounds; the rear axle, 1592 pounds with hubs and brake-drums; the front axle with hubs, 352 pounds; the transmission, 233 pounds; the clutch and case, 103 pounds; the frame without castings, 663 pounds; the front springs, 148 pounds; the rear springs, 544 pounds. Early tests of the engine showed 58 horsepower at 1350 revolutions per minute.

The completed truck is said to be the strongest, compared with the load it is designed to carry, ever turned out in this country. Every part has been enormously strengthened to withstand the rough usage of war. It carries more than 1000 pounds of dead weight in excess of commercial trucks of corresponding capacity. Owing to its increased weight, it is unsuited for normal use because of the large amount of gasoline and oil required for its operation; also, factories that have given free use of their patents have stipulated that the new truck was to be for government use only. Deliveries are expected to begin in January, and 35,000 trucks are to be made in the first half of the year.

Roughly, there were four major divisions of the engineering work—those relating to the engine, the transmission, the axles, and the other chassis parts. Each was manned by a corps of engineers and each unit represents a composite of the best features contributed, rather than the work of any one individual. In developing the engine, four or five makers cooperated by dividing the different parts between them, one making several parts not only for itself but for the other engine makers. The Continental Motor Mfg. Co. made the cylinders, gear-case cover and many small parts, such as pumps, bushings, etc. The Waukesha Motor Co. manufactured the cylinder heads, crank-case, intake and exhaust manifolds, roller push-rods, etc. The Wisconsin Co. made the lower part of the crank-case.

The Continental Motor Mfg. Co. received blueprints on September 9, and had an engine running within 19 days, 18 hours later, while the Waukesha Motor Co. had its first engine running within 11 days, 7½ hours from the time the blueprints reached its factory. These companies did not have to make all the patterns for castings or the dies for forgings, some of these having been made previously, but they had to do most of the machining and other operations on the parts. To make possible the completion of the units in record time, the Park Drop Forge Co. sank the dies for the crankshaft in seven days, an operation which is rarely completed in peace times in less than three weeks. The Werra Aluminum Castings Co. produced the pattern for the main crank-case and the first casting in five days, though usually from three to four weeks is required on much smaller jobs. The Continental pattern shop completed the pattern for the cylinder pairs in five days.

FORGING MACHINE DIE DESIGN[1]

RULES GOVERNING THE LENGTH OF UPSET IN TERMS OF BAR DIAMETER

EXPERIENCE shows that at least three-fourths of the failures in forging machine die design can be attributed to disregard of one or more of the fundamental laws. The only apparent way to make such a subject clear is by illustration; hence this information is presented in graphic form, with the hope that it will be of value to men in the shop, and will serve to reduce the expense for dies, the failure of which might be anticipated. Throughout this article the plan is followed of not taking into consideration unusual methods; trick heats; welding operations; or, in fact, any laboratory methods which, while possible under certain conditions, are impracticable in average shop practice. Consequently, while certain statements may appear to be too limited, they will, in the main, be found as applying to average conditions. It is possible to classify the majority of forging machine die problems under three rules or headings, which are as follows:

RULE 1. The limit of length of unsupported stock that can be gathered or upset in one blow without injurious buckling is not more than three times the diameter of the bar.

As an example, by reference to Fig. 1, if the diameter of the bar *A* to be upset is one inch, then the length of unsupported stock *B* which may be successfully gathered, cannot be more than three inches. This rule applies on all diameters of stock. As three diameters, however, is practically the limit, it is best to keep the actual working limit within two and one-half diameters; and where it can be done, a limit of two diameters is even better, as then less attention need be paid to the squareness of the end of the bar. On such upsets, as the heading tool advances, as indicated in Fig. 2, the stock will swell uniformly in all directions from the axis of the blank, and it can be carried to practically any thickness, as shown in Fig. 3, without any serious tendency to upset unevenly. It is immaterial whether the stock overhangs the face of the dies, as in Fig. 1, or whether part of the stock is gathered in the dies and part in the heading tool, as shown in Fig. 4; whether it is all upset in the gripping dies, as in Fig. 5, or all in the heading tool, as in Fig. 6—the fact must be kept in mind that such conditions represent cases where the stock is unsupported, and hence Rule 1 applying to three diameters or less of unsupported stock will apply. Many simple forgings come under this ruling, such as the bevel pinion forging shown in Fig. 7; the grease cup spring shackle bolt, Fig. 8, or the ring forging Fig. 9. In each case, the distance from the heated stock to the inner surfaces of the gripping die impression or the heading tool, is such that the stock is in reality unsupported.

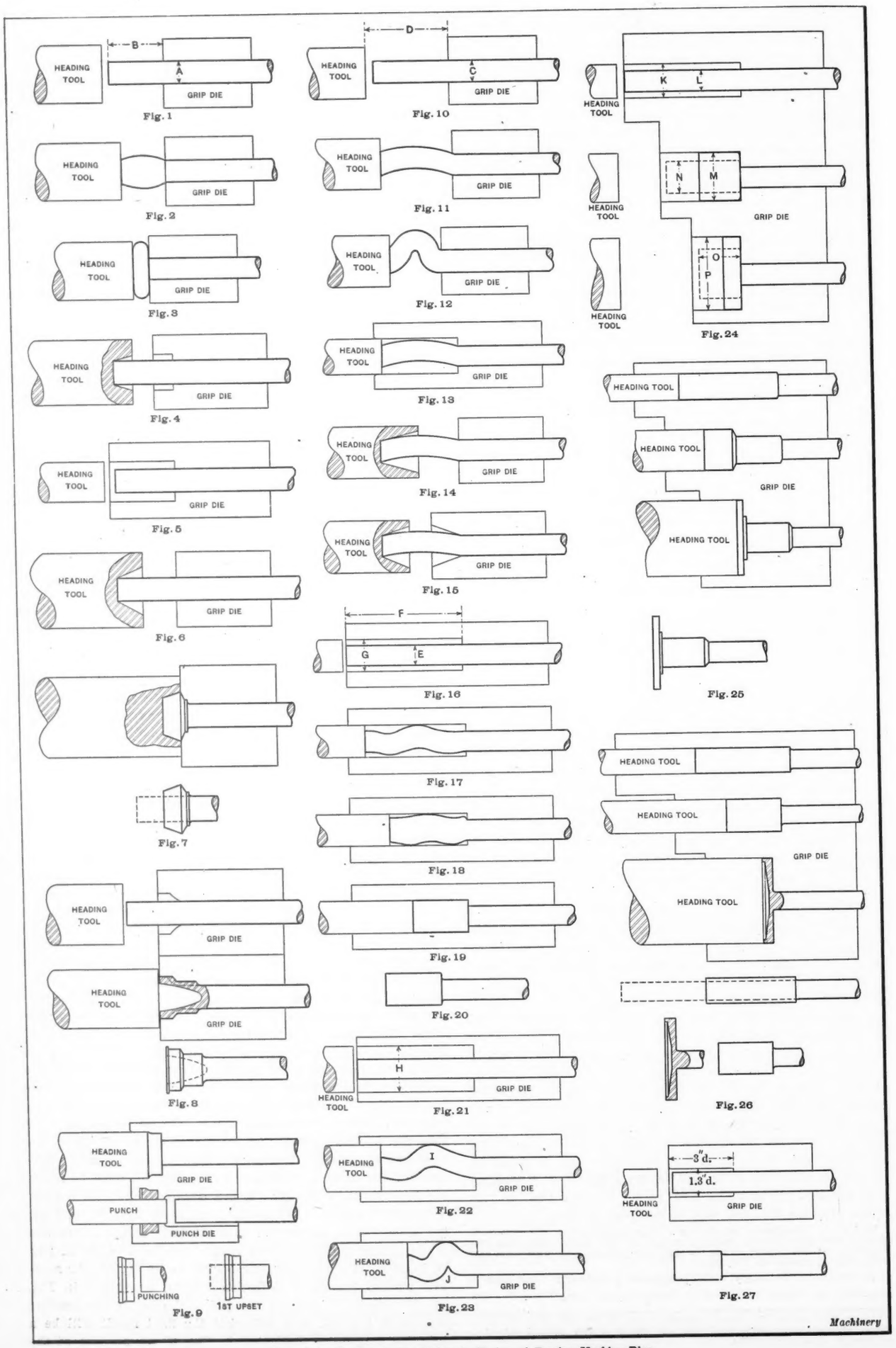
In order to prove the dependability of Rule 1, if an effort is made to upset a length of stock longer than three diameters, instead of upsetting uniformly, as shown in Figs. 2 and 3, the stock will buckle at a point near the middle, and result in more of the upset forming on one side of the center of the bar than on the other. As an example, in Fig. 10, assuming that the diameter of the bar *C* is one inch, and the length of unsupported stock *D* is four inches, then when the heading tool advances the stock will start to buckle, as shown in Fig. 11, and after it has once started, will, of course, continue, as illustrated in Fig. 12. It is merely an application of the general principle that under pressure given lengths of any material will either crush or bend. It is impossible to correct this condition by varying the point in the die where the upsetting takes place, as it will be readily seen in Figs. 13, 14 and 15, that the stock will buckle regardless of whether it is upset in the gripping dies, in the heading tool, or part in the gripping dies and part in the heading tool.

RULE 2. Lengths of stock more than three times the diameter of the bar can be successfully upset in one blow, provided the diameter of the upset made is not more than one and one-half times the diameter of the bar.

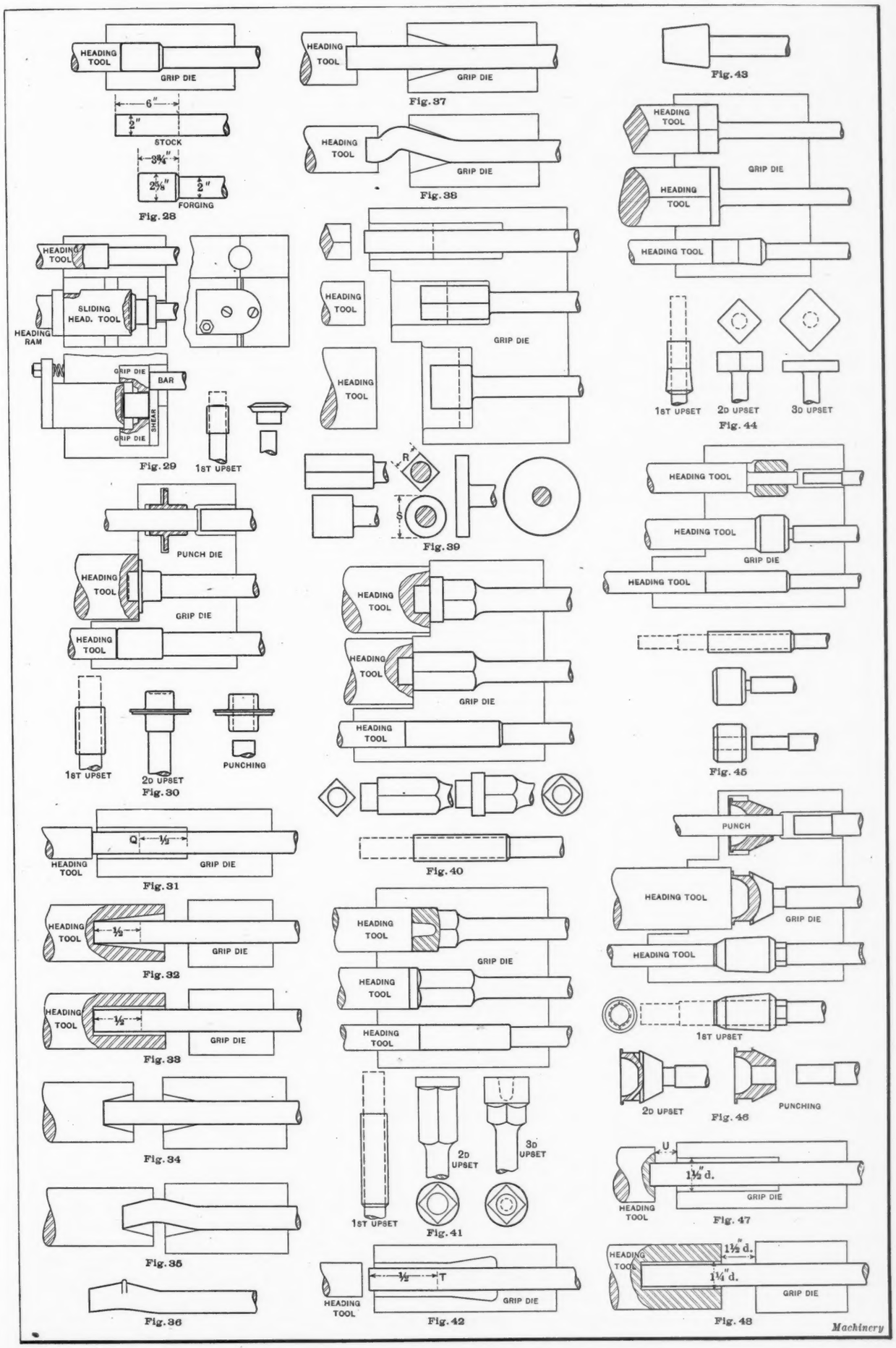
This rule while fairly well recognized requires a clear understanding in order to develop its practical possibilities. By reference to Fig. 16, assuming that the diameter of the bar *E* is one inch, the length of stock *F* to be upset is six inches, and that the diameter of the hole *G* in the die is not more than one and one-half inch, then when the upsetting begins, as in Fig. 17, the stock will at once buckle, but on account of the limited diameter of the hole *G* the stock soon comes in contact with the sides of the die. This prevents further buckling in this direction, and any additional upsetting must take place at some other point. The stock will frequently be found to buckle at several points, as in Fig. 17; but as the heading tool advances, the stock will gradually fill the impression in the die, as shown in Figs. 18 and 19, resulting in an upset, as in Fig. 20, the only objection being a fin around the end of the upset. If a forging is produced in a die in which the diameter of the hole, as at *H* in Fig. 21, is greater than one and one-half times the diameter of the bar, then when the upsetting begins the buckling effect at some point, generally near the middle of the unsupported stock, as at *I* in Fig. 22, is sufficient so that when the heading tool continues its advance, the stock on the opposite side from the buckled portion, as at *J*, Fig. 23, will "fold in," and leave a defect in the upset.

As in the case of Rule 1, while it is possible to make forgings in which the diameter of the opening in the die is as much as one and one-half times the diameter of the bar, nevertheless, this is very close to the limit, and in practice it is much better to keep the diameter of the upset not more than one and three-tenths times the diameter of the bar. The practical application of this law is in the ability to gather large amounts of stock by repeating the principle, as indicated in Fig. 24. In the first, or top impression, the diameter *K* of the recess in the die is not more than one and one-half times the diameter of the bar *L*. In the second impression, the diameter of the recess *M* is not more than one and one-half times the diameter of the previous upset *N*. In the last impression, the length of the upset *O* is well within the limit of Rule 1 regarding unsupported stock, so that no limit need be put on the diameter *P* of the last die impression. This principle is clearly shown in Fig. 25, in which, in both the first and second operations, the diameters of the impressions have been kept within this limit. The same principle applies to the first two operations in the upsets shown in Fig. 26. In upsets where the length of stock in the first operation is excessive it is generally necessary to keep the end of the bar at a lower temperature. Where it is desirable to hold carefully the size of some upset in which the stock requirement is not materially over three diameters in length, if the diameter of the impression in the die is made not more than one and three-tenths times the diameter of the bar, as in Fig. 27, the upset formed will be free from fins on the end of the upset, even if no special care is taken in heating. This is on account of the fact that where the length of the stock is not more than three diameters, the upsetting takes place quite uniformly throughout its length, and any buckling being limited, the friction of the stock along the side of the die does not become a factor. The forgings shown in Figs. 28, 29 and 30 come in this class. In handling all upsets requiring more than three diameters of stock the fact must always be kept in mind that the stock will first start to buckle at the middle of the unsupported portion, and as a result somewhat more than one-half the stock to be upset, as at *Q*, Fig. 31, must be inside the impression in the die. It can equally well be in a taper or straight hole in the heading ram, as in Figs. 32 and 33; but it is useless to attempt to make part of the impression in the gripping die and part in the heading tool, as in Fig. 34, because when the upsetting begins, as in Fig. 35, the stock will buckle, leaving a defective forging as shown in Fig. 36. To attempt to support the end of the bar in the heading tool, as in Fig. 37, does help, but the final result will be a defective forging as indicated in Fig. 38 on account of the

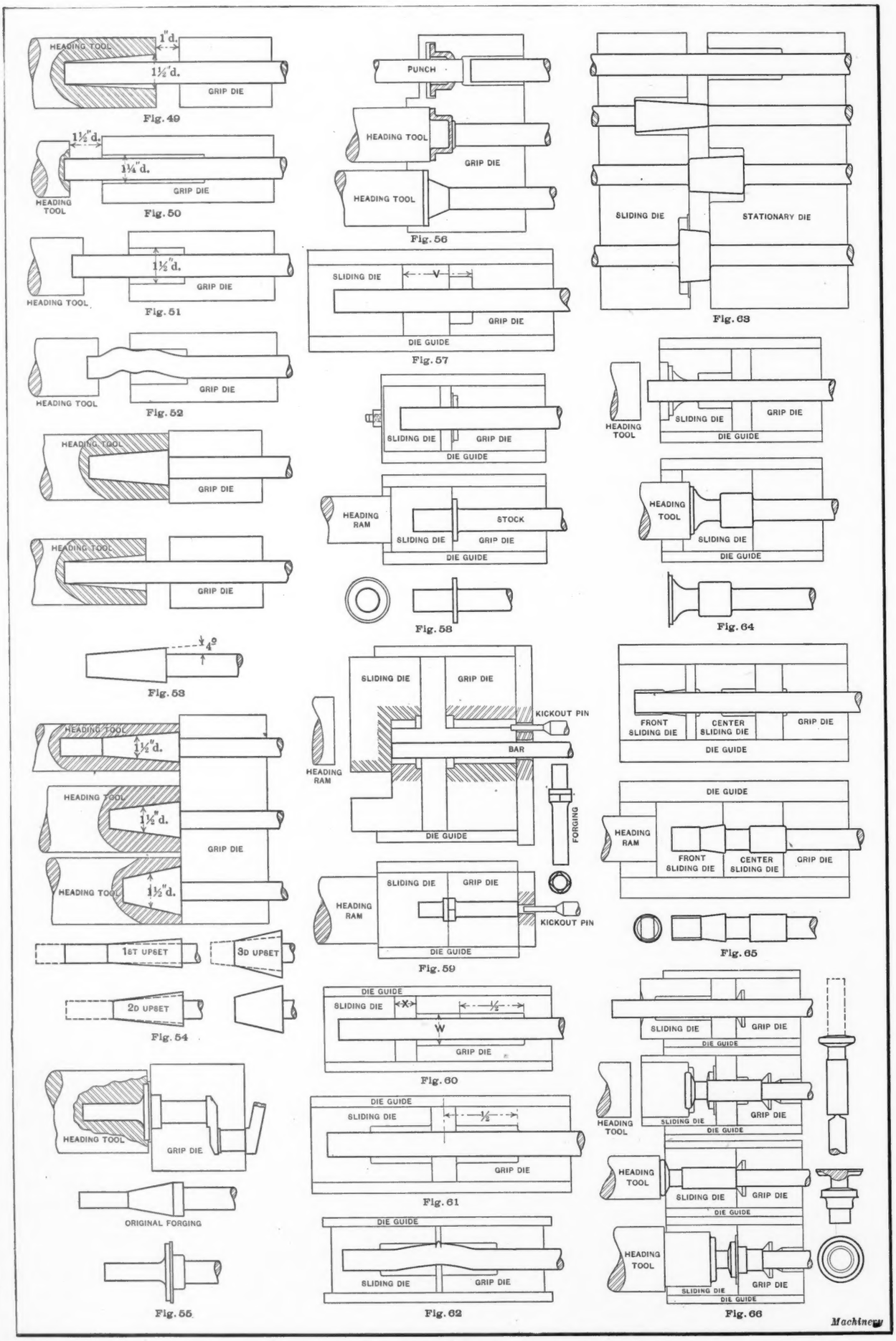
[1]Paper read before the fourth annual convention of the American Drop Forge Association at Cleveland, Ohio, by E. R. Frost, general manager, National Machinery Co., Tiffin, Ohio



Figs. 1 to 27. Illustrating Points in Design of Forging Machine Dies



Figs. 28 to 48. Illustrating Points in Design of Forging Machine Dies



Figs. 49 to 66. Illustrating Points in Design of Forging Machine Dies

lack of support near the middle of the upset, as suggested in Fig. 31.

Among the various ways to reduce the number of operations required to make large size upsets on small diameter bars, attention is called to the square hole scheme as shown in Fig. 39. Here an extra amount of stock is obtained in the first upset by making the first impression square, instead of round. The short diameter of the square hole *R* is made within one and one-half times the diameter of the bar. Consequently, the sides of the square impression in the die support the bar, and keep it from buckling; but the greater area of the square hole enables a larger amount of stock to be gathered than would be possible were the hole round. The next impression is made round, and the diameter of this impression *S* can be one and one-half times the long diameter, or in other words, the diameter across the corners of the previous square upset. The square corners, by coming in contact first with the sides of the die impression, also prevent the bar from buckling and allow a large amount of stock to be gathered. If the length of the stock as it leaves the second operation has been shortened sufficiently to come within the requirements of Rule 1, it can be formed in the last operation into any desired shape without regard to the diameter of the die impression. The practical application of such a method is shown in Figs. 40 and 41. Another method of increasing the amount of stock that can be gathered in one operation, is to keep the diameter of the impression in the die within the limit of Rule 2 for a distance of slightly more than one-half the length of the stock, as indicated at *T*, Fig. 42, and then to increase the size of the opening as shown. When the heading tool begins to upset the stock, it will, of course, buckle at *T*, but being supported by the die at this point, and by virtue of the fact that the friction along the side of the die will cause the forward end to upset first, the stock will gradually carry back in the die and produce a uniform upset, as shown in Fig. 43. The use of this method is also indicated in Figs. 44, 45, and 46.

RULE 3. In an upset requiring more than three diameters of stock in length, and in which the diameter of the upset is one and one-half times the diameter of the bar, the amount of unsupported stock beyond the face of the die must not exceed one diameter of the stock.

This rule, as will be noted, is a combination of Rules 1 and 2. As an example, if the stock to be upset, as in Fig. 47, is one inch in diameter by six inches long, and the diameter of the hole in the die is one and one-half inch, then the amount of stock *U* extending beyond the face of the die must not be more than one inch. However, if the diameter of the hole in the die, as in Fig. 48, is reduced below one and one-half diameter, the length of the unsupported stock beyond the face of the die can be correspondingly increased. If the diameter of the hole in the die is not over one and one-fourth times the diameter of the stock, the amount of stock beyond the face of the die may be increased to one and one-half times the diameter of the bar. This rule also applies to cases where the upsetting takes place in either straight or taper holes in the heading tools, as in Figs. 49 and 50. If an effort is made to allow a greater amount of stock to extend unsupported beyond the face of the dies, as in Fig. 51, the stock will buckle outside of the dies, as shown in Fig. 52. It will be readily seen that such a limited travel of the heading tool as at *U*, Fig. 47, would not provide sufficient stock to fill entirely the impression in the die; hence in view of the limited heading tool travel on account of Rule 3, many upsets can, to advantage, be made tapering, as indicated in Fig. 53. The taper upset possesses many valuable qualifications, particularly in that if the angle of the taper is approximately 4 degrees on each side, as indicated in Fig. 53, the increased diameter of the upset, as the heading tool advances, increases the pressure in the direction of the bottom of the impression in the taper tool, and more fully insures a uniform and well filled upset. Fig. 54 shows how progressive taper upsets can be made, keeping in mind in each case that the diameter of the taper hole near the middle of the unsupported portion of the stock must be kept within the requirement of Rule 2. A large amount of stock can be gathered in a few operations by this method, for while the first die impression is limited to the size of the bar, thereafter it is the dimensions of the taper upset that governs the size of the next die impression and not the diameter of the bar. The taper upset is also valuable in distributing the stock properly at the desired points, such as at the base of final upsets, in more easily filling a large flange, as in Fig. 55, or, by inverting the taper in securing the advantage of filling the outer flange, and enabling the second forming tool to more easily place the stock, as in Fig. 56.

Another form of die having great possibilities, but whose limits are more frequently misunderstood, is the sliding die, as shown in Fig. 57. Such dies are, of course, in quite general use, and are invaluable in upsetting stock at a considerable distance from the end of a bar. Rule 1, however, is still with us, as the total length of unsupported stock, measured from the bottom of the die impressions as at *V*, must not exceed three diameters of the bar. The practical application of this form of die is shown in Figs. 58 and 59. In case the length of unsupported stock is more than three diameters, as shown in Fig. 60, then both Rules 2 and 3 must be kept in mind as applying to the relative diameter of the upset, as at *W*, and the length of stock extending beyond the face of the die, as at *X*. Fig. 61 represents a failure in a sliding die, as the middle of the stock being beyond the face of the die, and hence unsupported, would buckle as indicated in Fig. 62.

In any extensive application of the sliding die, it is generally necessary to gather stock in several impressions, and here not only must Rules 2 and 3 be kept in mind, but it must also be remembered that the friction along the side of the die will cause the upsetting to take place near the front end of the die. For this reason, if the first upset is formed in the rear half of the dies, the second impression should be in the front half; the third impression in the rear half; the fourth impression in the front half, etc., in order in each case to bring that portion of the upset which naturally swells the most, into the bottom of the next impression where it is more difficult to carry it. The idea is shown in Fig. 63.

In the application of the sliding die, Fig. 64, an upset is made in the sliding portion of the die, and another at the front face of the die at the same stroke of the machine. Fig. 65 represents a double sliding die, in which two upsets are formed in the sliding portions of the dies, and in which the extreme front end of the stock is squeezed flat at the same time. Fig. 66 represents a double-deck sliding die in which the stock is gathered in the first impression, and the forging is practically cut from the bar. Upon being lowered to the final impression the upsetting is completed, and as the bar is turned one-fourth revolution, the forging is severed completely from the bar.

* * *

THE ALUMINUM INDUSTRY

According to a paper by F. A. Lidbury in the *Journal of the Western Society of Engineers*, the most important single electrochemical industry in point of power requirements, and also in point of value of product, is the aluminum industry. So far as can be ascertained, there is something like 130,000 kilowatts of capacity installed in this country at present for the purpose of making aluminum. In addition to these, there appear to be about 60,000 kilowatts either being installed at present or contemplated. This indicates that the requirements of the aluminum industry alone in this country lie between 100,000 and 200,000 kilowatts. The demand for aluminum seems to be increasing every year, and this is not, to a great extent, a war demand, but the increase has come about by the rapid extension of the general uses of aluminum, as, for instance, in the automobile. Its use in the automobile is not only direct, but indirect, and includes the manufacture of certain steels and of steels of a nature that enables small light parts to be used in places demanding great strength in the automobile where a few years ago carbon steel of much greater dimensions had to be used.

* * *

Brazil's exports of manganese have increased from 122,300 tons, in 1913, to 503,130 tons, in 1916.

EFFICIENCY IN TOOL DESIGNING

MAKING TOOL DESIGNS—SATISFACTORY DRAWING PAPER—CHECKING A DRAWING

BY F. B. JACOBS [1]

TO the average man, "efficiency" brings to mind an elaborate series of motion and time studies, by means of which production is increased by eliminating all useless motions and routing the work to the best advantage. The selection and maintenance of suitable tools and the type of individual entrusted to perform specific operations are, of course, equally important factors.

In the drafting-room, however, it is impossible to adopt time and motion studies, because the human element is the all-important factor to consider, as the work is of a creative instead of a productive nature. For instance, how impracticable it would be to limit an inventor to a specified amount of time in which to design a machine for a specific purpose. Such a theory would be impossible to put into practice, as the action of the human mind, as far as originating ideas is concerned, cannot be governed by hard and fast rules, aside from the fact that a healthy individual is capable of putting forth his best efforts when not under the influence of an artificial stimulant of any kind or laboring under mental unrest of an abnormal kind caused by unpleasant home or other social surroundings. Efficiency in the drafting-room is practicable, however, if we confine our efforts along reasonable lines wherein efficient results are the outcome of the systematic handling of the work in question instead of attempting to set a stated time limit for the production of a given amount of work.

The opinion seems to be prevalent that any old place where a few drawing tables can be spread is good enough for the draftsman. Why this idea is accepted it is hard to say, but an inspection of the tool-drafting departments of many large concerns shows that a poor location is often chosen. One tool-designing department where the men were compelled to work by artificial light day in and day out, notwithstanding the fact that the concern in question had acres of idle floor space that could be utilized, was located in this place because it was near the chief engineer's office and the tool-room. But why cause the tool designers to suffer continual eye strain simply to accommodate the chief engineer and the tool-room foreman? A little time was occasionally saved in one way, to be sure, but it was greatly offset by the inefficiency that was bound to result from the tool designers continually working under the glare and heat of electric lights. Locating the tool-designing department near the production department is another detriment to effective work; the continual noise and disturbance is nerve racking, to say the least, to the man who is endeavoring to concentrate his mind on mathematical and other obtruse problems that are a necessary part of the tool designer's work.

After selecting a suitable location for the tool-designing department, where unnecessary noise and other confusion is eliminated and where the light is good, the next question to consider is the means of getting and holding the best tool designers obtainable. While a comparatively inexperienced man, a trade- or correspondence-school graduate, for instance, can be readily broken in as a tracer or detail draftsman, a good tool designer cannot be thus obtained. To carry on this class of work successfully calls for long experience and broad training, which is best acquired by working in several manufacturing centers. Good tool designers are scarce and are not to be had by simply putting an advertisement in a daily paper. Besides, it costs from $100 to $500 to break in a man in a responsible position, so that the surest way to retain good men who can be depended on is to make their surroundings as pleasant as possible and to pay the maximum wages for a given locality. It is well known that competent machinists and toolmakers will not stay in a dark, dirty shop any longer than is absolutely necessary, and the same rule holds good with the tool designer, for, like his brothers in the shop, he has generally roamed around a bit and knows what constitutes good surroundings. As a result, the concern with uncongenial surroundings is bound to retain only the incompetents, while the better workmen seek pleasanter situations. Of course, all men should be loyal to their employers, this being one of the fundamental principles of successful cooperation between labor and capital; nevertheless it is much easier to remain loyal where conditions are good.

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Methods of Making Tool Designs

If three tool designers, each of recognized ability, are given a similar piece of work with the injunction to design a jig or fixture for it, three totally different designs, all practicable no doubt, will be the result. This is caused, of course, by each one following his own inclinations, and if a fixed standard of design is desired, the several tool designers should work under the supervision of a chief whose ability and record are known. It is not the intention to convey the thought that all the designer's original ideas should be ignored, but when the average tool designer is thrown wholly on his own resources he is inclined to introduce too much originality in his efforts simply for the purpose of stamping his work with a mark of personal distinction, as it were. He wishes his work to stand out in a class by itself. Thus one man might use tapered dowel-pins, while another prefers straight ones. Again, one man might use flat-head screws, while another designates hexagonal-head cap-screws. One designer might favor light ribbed construction for jig bodies, while his neighbor insists on heavy, plain construction. One designer may prefer to fasten guide blocks on the bottom of milling fixtures by means of screws, while another designs the blocks integral with the base, and so on. It is evident that this variance of ideas is bound to lead to confusion, notwithstanding the fact that all practicable ideas have their good points, so where it is desired to maintain any kind of standard it is necessary for the chief designer to formulate a fixed standard, as far as possible, and insist that the men stick to it.

The work of the tool designer consists of designing tools and fixtures to facilitate the duplication of machine parts, it being understood, of course, that his drawings are for the purpose of conveying full and clear instructions to the toolmaker. It has been truly stated that a man can produce almost anything if given time enough, but as tool designing is an expensive branch of engineering work at best, wherein slight errors often have far-reaching results, it is necessary for the designer to proceed along practical lines, bearing in mind the fact that he is not the only person to be suited.

To change a drawing several times during the course of its completion is an expensive proceeding, especially if the lines have been drawn in heavily; and, besides, the appearance of the finished drawing looks far from satisfactory and often makes a poor print in cases where the blueprint is made directly from the designer's drawing. To the end that unnecessary work may be avoided, it is a good plan for the designer to make his original lay-out with light lines, which can be easily erased if necessary, and after a plan and two elevations and perhaps a section have been sketched in, the work should be examined by the chief tool designer.

If the acceptance of the design rested wholly with the tool designer and the chief draftsman, they could, no doubt, easily come to a quick agreement as to what was suitable. However, the head toolmaker, efficiency engineer, production engineer, shop foremen, and perhaps a few others are also interested in the tools that are to be made for certain purposes. Thus, where harmony is to prevail, which, by the way, is absolutely necessary if efficient production in the shop is desired, everyone concerned should be given an opportunity to pass on the tool designs submitted before the drawings are detailed and billed out to the tool-room. These tool-committee meetings consume time, to be sure, but when several men get together around a table for the sole purpose of passing on the merits

of several tool designs, the general discussion of the various points involved nearly always results in the acceptance of efficient designs and the rejection of poor ones.

Satisfactory Drawing Paper

The proper kind of paper to use for making tool drawings is a question upon which there is a great diversity of opinion. Heavy white or buff paper is sometimes used; and while this produces a very neat drawing, especially if it is inked in, there is the extra cost of making a tracing from which the blueprint for the tool-room is taken. The original drawings are sometimes given a coat of white shellac and then sent to the tool-room; while this eliminates the work of making the tracing and blueprint, the original drawing is often nearly ruined in the tool-room through contact with dirty hands and from other causes. In addition, the shellac coating makes it difficult to change the drawing later. The original drawing is sometimes made directly on tracing paper, but this material is easily torn, and as tool drawings should be filed away for future reference, they should be made on more serviceable material. In many up-to-date drawing-rooms, tool drawings are made on vellum paper, from which a blueprint is taken. This material is expensive, compared with some papers, and to the beginner it is a little difficult to work on. It is quite transparent, however, exceedingly tough, and can be handled repeatedly without tearing, that is, of course, if a little care is used in handling it. The drawings can be made either in pencil or in ink, and in either case the material stands erasure well in case changes are necessary. Ink does not seem to penetrate it, so that inked lines are readily removed with an ordinary eraser such as is used for rubbing out pencil lines. It is the general practice, however, to make the drawing in pencil only, and if a medium grade of lead is used, say 2 H, the lines will be heavy enough to make a good blueprint.

Checking a Drawing

After a tool drawing is completed, it should be checked for errors, for a slight error on the draftsman's part often entails a heavy expense. On first thought it would appear that a competent workman should not make mistakes, but the draftsman, like any other worker, is bound to make an error once in a while. Roughly speaking, there are three methods used in checking tool drawings. The simplest method, perhaps, is for the tool draftsman to check his own work, being guided by a simple series of printed or typewritten questions that cover the errors generally made by the average draftsman. This method is not very satisfactory, when taken as a whole, owing to the fact that we all are prone to overlook mistakes on our own part. For instance, the draftsman might use the wrong formula in his calculations, in which case no amount of checking will disclose the error until the correct formula is applied. Mistakes of this kind, by the way, are of common occurrence. Another method is to have one man's work checked by one of his fellow-workers, whose work, in turn, is checked by another, and so on. While this is a little better than individual checking, it leaves much to be desired, owing to the fact that in every drafting-room there are a few who consider themselves a little smarter than their fellow-workers, and when given a little authority for the time being they make themselves obnoxious. It can be truthfully said that this system of checking often causes hard feelings among the men, which state of affairs has a tendency to lower efficiency, for the individual has yet to be borne who can do his best work while feeling grouchy, whether the cause is real or imaginary.

The most satisfactory method is to employ men to do nothing but checking. One checker for every ten tool designers is a reasonable ratio in cases where the checkers devote all their time to checking and where the designers can be depended upon to make the minimum amount of errors. A reliable checker should be a draftsman of wide experience. Not all draftsmen, however, make good checkers, as this work calls for qualifications not possessed by every draftsman. The checker must be thorough and accurate, fond of detail by nature, and above all he must possess diplomacy to a marked degree to hold the good will of the men whose drawings come under his inspection. Since the checker is held responsible for errors that pass him, he should check systematically, being guided by accepted rules. There are many systems for checking tool drawings; the following is successfully used by one of the largest automobile manufacturers of the Middle West:

1. Check size of sheet.
2. Check projections.
   - A. Check center lines.
   - B. Are sections properly labeled?
   - C. Is drawing perfectly clear?
   - D. Is drawing neat, are figures plain, and will it make a good print?
3. Check design.
   - A. Check for weight.
   - B. Check for weakness.
   - C. Check for molding, forming, or forging.
   - D. Check for cheapness.
   - E. Check for machining.
   - F. Check for interferences.
   - G. Check for assembling.
   - H. Check for under-cuts, fillets, and chamfers.
   - I. Are bosses large enough?
4. Check for dimensions.
   - A. Check for correct dimensions.
   - B. Check for arrowheads.
   - C. Check for scale.
   - D. Check for duplicate dimensions.
   - E. Check for standard drills and reamers.
   - F. Are all necessary dimensions given?
   - G. Are all necessary finish marks given?
5. Check title block.
   - A. Check title of drawing.
   - B. Check material.
   - C. Check number of parts required.
   - D. Check order number.
   - E. Check operation intended for.
   - F. Check machine to be used on.
   - G. Check date.
   - H. Check draftsman's signature.
6. General notes.
   - A. Are all parts necessary to complete unit detailed?
   - B. Can any detailed parts, such as nuts, screws, etc., be purchased?
   - C. Are chucking rings, pot castings, or machining lugs necessary?
   - D. Is necessary material called for in stock?

The checker should order all necessary changes by writing them on a slip, which is handed to the draftsman together with the drawing that has been checked. The draftsman then makes the necessary changes, checking off the items on the slip as he makes his alterations. While the checker should have the authority to order such changes as are necessary, he should exercise diplomacy not to abuse this authority. As an illustration, the heading "Check design" does not imply that the checker has unlimited authority to order the draftsman to change the design for one that happens to suit him a little better. If the design approved by the chief draftsman and tool committee is practicable, the checker should let it stand, bearing in mind the fact that it is sometimes a good plan to let well enough alone. While it goes without saying that a reliable checker does as much as any one other person in the tool-drafting room to promote efficiency, he should not take himself too seriously. He has a certain amount of authority, to be sure, but he should not abuse this authority by ordering slight changes just for the sake of making others obey orders.

A whole book on efficient tool designing could, no doubt, be written if one could spare the time and were reasonably sure of finding a publisher who would consider the manuscript. After all is said, however, efficiency in the tool-designing department consists mainly in having a fixed system, working to the same, and following a few simple details as illustrated in this article.

* * *

The British government has decided that the construction of the proposed tunnel under the British channel is not to be proceeded with until after the war. The tunnel could not be completed so as to be of any particular assistance during the war. Had such a tunnel been ready at the beginning of the war, however, it might have been of considerable value; but the present time would be inopportune for the beginning of so great an undertaking.

OPERATING INSTRUCTIONS FOR HOBBING MACHINES

INSTRUCTIONS FOR GOULD & EBERHARDT 72- BY 20-INCH AUTOMATIC SPUR AND HELICAL GEAR HOBBING MACHINE

BY ROBERT E. NEWCOMB [1]

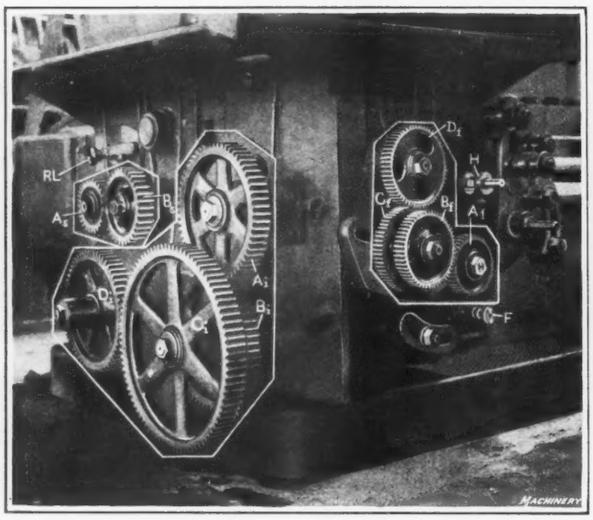

Fig. 1. A_1, B_1, C_1, D_1, Index or Dividing Gears; A_f, B_f, C_f, D_f, Feed Gears; A_s, B_s, Cutter Speed Gears; F, Pin to set Machine for cutting Spur and Helical Gears (Pin in Upper Hole for Spur Gears); H, Crank Handle for imparting Hand Movement to Stanchion; RL, Knob for reversing Direction of Cutter Rotation

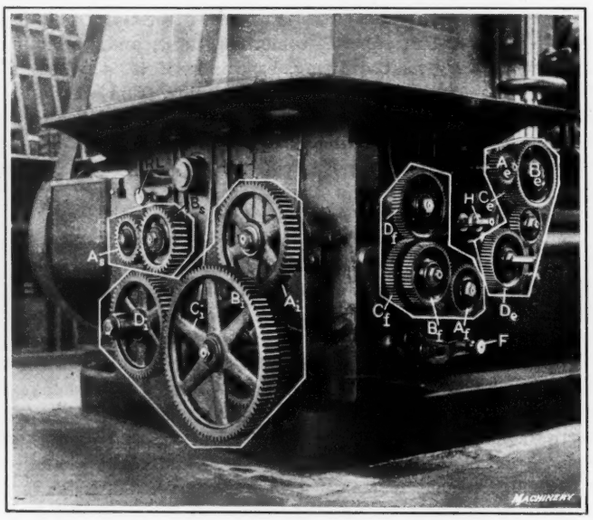

Fig. 2. A_1, B_1, C_1, D_1, Index or Dividing Gears; A_f, B_f, C_f, D_f, Feed Gears; A_c, B_c, C_c, D_c, Lead Change-gears; A_s, B_s, Cutter Speed Change-gears; F, Pin in Lower Hole for hobbing Helical Gears; H, Crank Handle for Hand Movement of Stanchion; RL, Knob for reversing Direction of Cutter Rotation

DETAILED instructions for the guidance of operators of the Gould & Eberhardt 72- by 20-inch automatic spur and helical gear hobbing machine are given in the following article. These instructions were developed at the Deane Steam Pump Works of the Worthington Pump & Machinery Corporation at Holyoke, Mass. They have been found sufficiently explicit so that men with no experience in the operation of gear-hobbing machines, but with average mechanical ability, have been able to produce satisfactory results.

1. Place the hob cutter on the cutter-arbor and secure it by means of the nut. Set a space of the cutter central and to coincide with the cutter-setting gage in the swivel slide (Fig. 10). Setting the space of the cutter central is very important, especially when cutting gears having less than thirty teeth. It is good practice to set a different space central for each gear, as this will eliminate uneven wear.

2. To set the cutter, the nuts on the spindle bearing are loosened. The cutter-spindle bearings are then adjusted lengthwise by means of small adjusting screws, until the space matches exactly with the cutter-setting gage. Then the spindle bearing bolts are securely fastened and the cutter-setting gage withdrawn from the cutter.

3. The swivel slide is now adjusted to the proper angle for the gear to be cut, according to instructions in Figs. 3 and 4. These charts give the proper position of the cutter in relation to the perpendicular, which depends upon whether the cutter is right- or left-hand, and whether the gear is a spur gear or a right- or left-hand helical gear.

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Gears to be Generated	Hob	Position of Cutter Reverse Knob	Direction of Rotation of Table and Hob, also Position of Swiveling Head	Index Dividing Gears	Feed Change Gears	Lead Change Gears
Right Hand Spiral Gear	Right Hand	IN	$\alpha' = \alpha - B$	OMIT INTERMEDIATE	OMIT INTERMED.	USE INTERMED.
	Left Hand	IN	$\alpha' = \alpha + B$	USE INTERMEDIATE	USE INTERMED.	USE INTERMED.
Left Hand Spiral Gear	Right Hand	OUT	$\alpha' = \alpha + B$	USE INTERMEDIATE	OMIT INTERMED.	OMIT INTERMED.
	Left Hand	OUT	$\alpha' = \alpha - B$	OMIT INTERMEDIATE	USE INTERMED.	OMIT INTERMED.
EXAMPLE: Problem—Right Hand Spiral Gear, 90 teeth, 1½ Normal dia. pitch or pitch of Hob 30° Spiral Angle of Gear, Right Hand Hob ($B = 4°$)—Feed = 0.12″ per revolution of table.						
Right Hand Spiral Gear	Right Hand	IN	$\alpha' = \alpha - B$ $= 30°4'$ $= 26°$	A=60 B=50 C=90 D=80	A=60 B=48 C=80 D=80	D=30 B=60 C=65 A=58

Machinery

Fig. 3. Data and Diagrams for Arrangement of Cutter-head, Hob and Gears for cutting Helical Gears. Note: For cutting Helical Gears, Pin F, Fig. 2, on Feed Gear Arm is inserted in Lower Hole

4. The gears to rotate the cutter in the forward direction are then engaged by shifting the cutter reverse knob *RL* at the back of the machine, Fig. 12. For position of cutter knob for spur gears, refer to Fig. 4, and for helical gears, refer to Fig. 3.

5. The work-mandrel is now inserted in the work-table, and the blank placed on it and securely fastened, care being taken to see that the hole and the face of the blank by which it is clamped are entirely free from all dirt and burrs, and that the blank is of proper diameter. For gears of small diameter, use the outer support arm shown in Fig. 8. For gears of large diameter, remove the outer support arm, and support the gear blank rigidly at the rim, using the segment rim supports.

6. Now test the gear blank for concentricity with a test indicator, and make sure that the periphery revolves perfectly true with the hole. This is important, and is necessary to obtain smooth running gears.

7. Lower the cutter-slide by power until the center of the cutter is opposite the face of the gear blank. This is accomplished by moving lever *C* on the right-hand side of the machine, Fig. 12, to engage the cutter traversing mechanism and then operating lever *D* at the right of the machine to connect with the power mechanism.

8. Adjust the stanchion toward the gear blank, until the outside diameter of the cutter just grazes the periphery of the gear blank. This is accomplished by moving lever *C* to engage the stanchion traversing mechanism and then operating lever *D* to connect with the power of the mechanism. Take care that the blank is not cut by

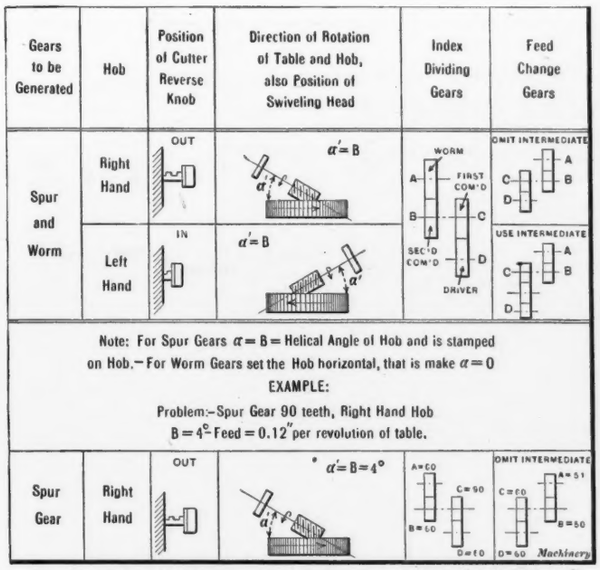

Fig. 4. Data and Diagrams for Arrangement of Cutter-head, Hob and Gears for cutting Spur Gears. Note: For cutting Spur Gears, Pin F, Fig. 1, is inserted in Upper Hole

the cutter while making this adjustment. Loosen stanchion bolts before adjusting stanchion.

9. The cutter is now raised above the upper edge of the gear blank similar to the way in which it was lowered, as described under Step 7. The stanchion is now adjusted for the proper depth of tooth by means of crank handle *H*, Fig. 2, on the right-hand side of the machine. The proper depth can be read from the dial provided near the lead gears at the point marked *H*. The setting of the gear blank for the proper depth as outlined should not be relied upon to give the proper thickness at the pitch line. The thickness of tooth at the pitch line should be carefully calipered with a tooth gage or a Brown & Sharpe gear-tooth caliper. This measuring should be done when the center of the cutter has just passed the upper edge of the blank. When the stanchion has been adjusted to give the proper thickness of tooth at the pitch line, it should be rigidly secured to the base by the bolts provided for the purpose.

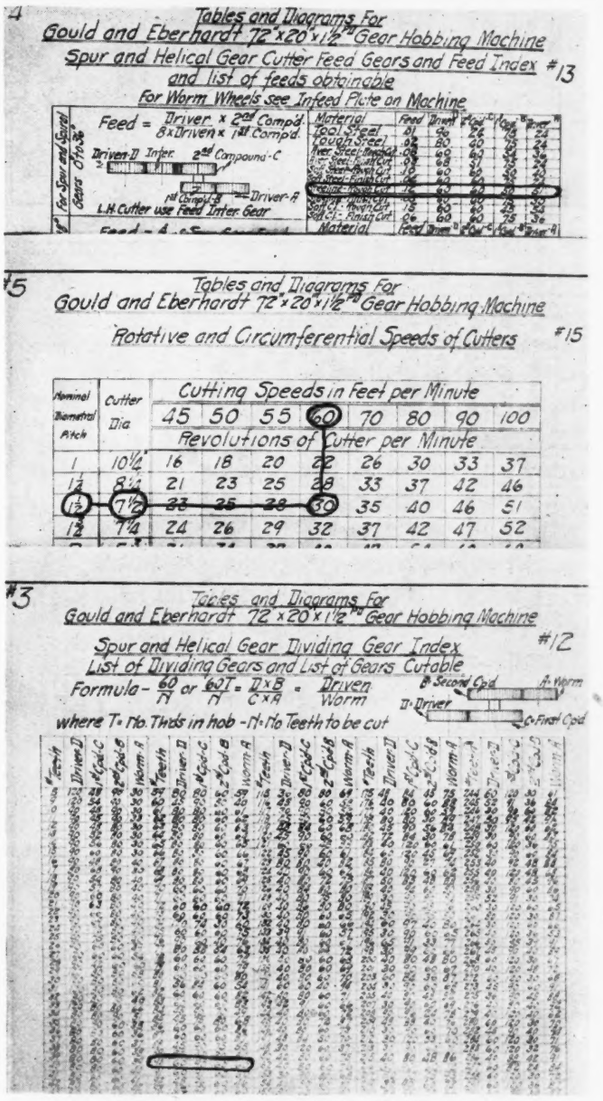
#4
Tables and Diagrams For
Gould and Eberhardt 72"x20"x1½" Gear Hobbing Machine
Spur and Helical Gear Cutter Feed Gears and Feed Index #13
and list of feeds obtainable
For Worm Wheels see Infeed Plate on Machine
#5
Tables and Diagrams For
Gould and Eberhardt 72"x20"x1½" Gear Hobbing Machine
Rotative and Circumferential Speeds of Cutters #15
Nominal Diametral Pitch
Cutter Dia
Cutting Speeds in Feet per Minute
45 50 55 60 70 80 90 100
Revolutions of Cutter per Minute
#3
Tables and Diagrams For
Gould and Eberhardt 72"x20"x1½" Gear Hobbing Machine
Spur and Helical Gear Dividing Gear Index #12
List of Dividing Gears and List of Gears Cutable
Formula - 60/N or 60T = D×B/C×A = Driven/Worm
where T = No. Thds in hob - N = No. Teeth to be cut

Fig. 5. Diagram showing Proper Selection of Index or Dividing Gears, Feed Change-gears and Cutter Speed Change-gears for the Spur Gear Problem

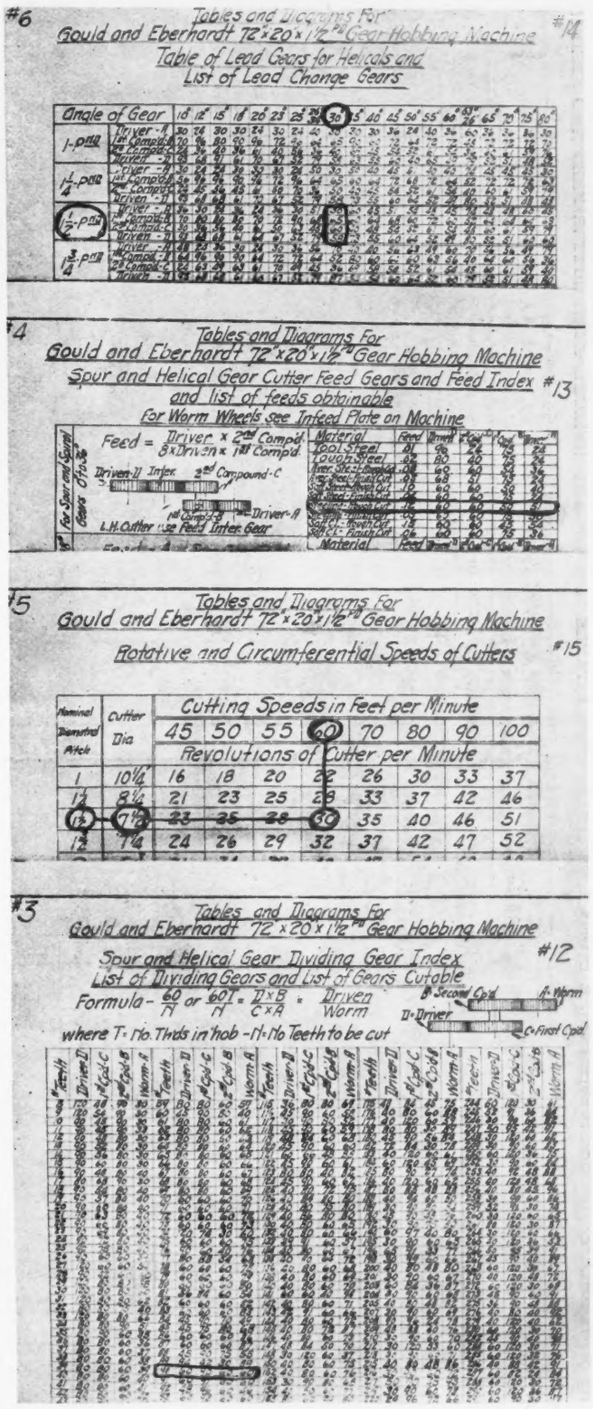
#6
Tables and Diagrams For
Gould and Eberhardt 72"x20"x1½" Gear Hobbing Machine #14
Table of Lead Gears for Helicals and
List of Lead Change Gears
Angle of Gear
#4
Tables and Diagrams For
Gould and Eberhardt 72"x20"x1½" Gear Hobbing Machine
Spur and Helical Gear Cutter Feed Gears and Feed Index #13
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Fig. 6. Diagram showing Proper Selection of Index or Dividing Gears, Feed Change-gears and Cutter Speed Change-gears for Helical Gear Problem

10. The feed gears are now selected, as per instructions in Table 2, and located with proper relation to each other, as

TABLE 1. SPUR AND HELICAL GEAR DIVIDING GEAR INDEX

#3

Tables and Diagrams For
Gould and Eberhardt 72 x 20 x 1 1/2 PD Gear Hobbing Machine

#12

Spur and Helical Gear Dividing Gear Index
List of Dividing Gears and List of Gears Cutable

Formula - $\frac{60}{N}$ or $\frac{60T}{N} = \frac{D \times B}{C \times A} = \frac{\text{Driven}}{\text{Worm}}$

B-Second Cp'd, A-Worm, D-Driver, C-First Cp'd

where T = No. Thds in hob - N = No Teeth to be cut.

No. Teeth	Driver-D	1st Cpd-C	2nd Cpd-B	Worm-A	No. Teeth	Driver-D	1st Cpd-C	2nd Cpd-B	Worm-A	No. Teeth	Driver-D	1st Cpd-C	2nd Cpd-B	Worm-A	No. Teeth	Driver-D	1st Cpd-C	2nd Cpd-B	Worm-A	No. Teeth	Driver-D	1st Cpd-C	2nd Cpd-B	Worm-A
8	120	48	90	30	39	80	80	60	39	115	30	80	80	69	115	48	90	43	78	144	60	120	30	81
9	120	54	90	30	40	25	80	80	40	116	43	90	60	52	116	40	80	40	58	145	60	90	48	87
10	60	48	90	30	41	80	80	60	41	117	30	80	60	39	117	48	90	40	78	146	60	90	48	88
11	60	44	90	30	42	80	80	60	42	118	43	90	60	59	118	40	80	40	59	147	60	90	48	89
12	60	48	90	30	43	80	80	60	43	119	34	80	60	68	119	48	90	40	79	148	60	90	48	89
13	60	52	90	30	44	80	80	60	44	120	25	80	60	48	120	48	90	40	80	149	60	90	48	90
14	90	84	80	30	45	80	80	60	45	121	62	90	80	93	121	40	80	40	61	150	60	120	36	75
15	90	60	80	30	46	80	80	60	46	122	45	90	80	60	122	48	90	40	81	151	60	90	48	91
16	90	48	80	30	47	80	80	60	47	123	80	90	80	82	123	40	80	40	62	152	60	90	48	92
17	90	68	80	40	48	80	80	60	48	124	40	90	80	62	124	48	90	40	82	153	60	90	48	93
18	90	54	80	40	49	80	80	60	49	125	40	90	80	63	125	40	80	40	63	154	60	90	48	94
19	90	57	80	40	50	80	80	60	50	126	40	90	80	64	126	48	90	40	84	155	60	90	48	95
20	90	60	80	40	51	60	80	60	51	127	40	90	80	65	127	40	80	40	64	156	60	90	48	96
21	90	63	80	40	52	60	80	60	52	128	40	90	80	66	128	48	90	40	85	157	60	120	48	98
22	90	66	80	40	53	60	80	60	53	129	40	90	80	67	129	40	80	40	65	158	60	120	36	79
23	90	69	80	40	54	60	80	60	54	130	40	90	80	68	130	48	90	40	86	159	60	120	48	99
24	90	72	80	40	55	60	80	60	55	131	40	90	80	69	131	40	80	40	66	160	60	120	48	100
25	90	75	80	40	56	60	80	60	56	132	40	90	80	70	132	48	90	40	88	161	60	120	48	101
26	90	78	80	40	57	60	80	60	57	133	40	90	80	71	133	40	80	40	67	162	60	120	48	102
27	120	60	60	54	58	60	60	60	58	134	40	80	60	68	134	48	90	40	89	163	60	120	48	103
28	90	42	60	60	59	60	60	60	59	135	40	80	60	69	135	40	80	40	68	164	60	120	48	104
29	120	58	60	60	60	60	60	60	60	136	40	80	60	70	136	48	90	40	90	165	60	120	48	105
30	90	60	60	60	61	60	60	60	61	137	40	80	60	71	137	40	80	40	69	166	60	120	48	106
31	120	60	60	62	62	60	60	60	62	138	40	80	60	72	138	48	90	40	91	167	60	120	48	107
32	90	48	60	60	63	60	60	60	63	139	40	80	60	73	139	40	80	40	70	168	60	120	48	108
33	120	60	60	66	64	60	60	60	64	140	40	80	60	74	140	48	90	40	92	169	60	120	48	109
34	90	51	60	60	65	60	60	60	65	141	40	80	60	75	141	40	80	40	71	170	60	120	48	110
35	90	54	60	60	66	60	60	60	66	142	40	80	60	76	142	48	90	40	93	171	60	120	48	111
36	90	57	60	60	67	60	60	60	67	143	40	80	60	77	143	40	80	40	72	172	60	120	48	112
37	90	60	60	60	68	60	60	60	68	144	40	80	60	78	144	48	90	40	94	173	60	120	48	113
38	90	63	60	60	69	60	60	60	69	145	40	80	60	79	145	40	80	40	73	174	60	120	48	114
39	90	66	60	60	70	60	60	60	70	146	40	80	60	80	146	48	90	40	95	175	60	120	48	115
40	90	60	60	60	71	60	60	60	71	147	40	80	60	81	147	40	80	40	74	176	60	120	48	116
41	90	72	60	60	72	60	60	60	72	148	40	80	60	82	148	48	90	40	96	177	60	120	48	117
42	90	75	60	60	73	60	60	60	73	149	40	80	60	83	149	40	80	40	75	178	60	120	48	118
43	90	78	60	60	74	60	60	60	74	150	40	80	60	84	150	48	90	40	97	179	60	120	48	119
44	90	81	60	60	75	60	60	60	75	151	40	80	60	85	151	40	80	40	76	180	60	120	48	120
45	90	84	60	60	76	60	60	60	76	152	40	80	60	86	152	48	90	40	98					
46	90	87	60	60	77	60	60	60	77	153	40	80	60	87	153	40	80	40	77					
47	90	90	60	60	78	60	60	60	78	154	40	80	60	88	154	48	90	40	99					
48	90	90	60	60	79	60	60	60	79	155	40	80	60	89	155	40	80	40	78					
49	90	90	60	60	80	60	60	60	80	156	40	80	60	90	156	48	90	40	100					
50	90	90	60	60	81	60	60	60	81	157	40	80	60	91	157	40	80	40	79					
51	90	90	60	60	82	60	60	60	82	158	40	80	60	92	158	48	90	40	101					
52	90	90	60	60	83	60	60	60	83	159	40	80	60	93	159	40	80	40	80					
53	90	90	60	60	84	60	60	60	84	160	40	80	60	94	160	48	90	40	102					
54	90	90	60	60	85	60	60	60	85	161	40	80	60	95	161	40	80	40	81					
55	90	90	60	60	86	60	60	60	86	162	40	80	60	96	162	48	90	40	103					
56	90	90	60	60	87	60	60	60	87	163	40	80	60	97	163	40	80	40	82					
57	90	90	60	60	88	60	60	60	88	164	40	80	60	98	164	48	90	40	104					
58	90	90	60	60	89	60	60	60	89	165	40	80	60	99	165	40	80	40	83					
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60	90	90	60	60	91	60	60	60	91	167	40	80	60	101	167	40	80	40	84					
61	90	90	60	60	92	60	60	60	92	168	40	80	60	102	168	48	90	40	106					
62	90	90	60	60	93	60	60	60	93	169	40	80	60	103	169	40	80	40	85					
63	90	90	60	60	94	60	60	60	94	170	40	80	60	104	170	48	90	40	107					
64	90	90	60	60	95	60	60	60	95	171	40	80	60	105	171	40	80	40	86					
65	90	90	60	60	96	60	60	60	96	172	40	80	60	106	172	48	90	40	108					
66	90	90	60	60	97	60	60	60	97	173	40	80	60	107	173	40	80	40	87					
67	90	90	60	60	98	60	60	60	98	174	40	80	60	108	174	48	90	40	109					
68	90	90	60	60	99	60	60	60	99	175	40	80	60	109	175	40	80	40	88					
69	90	90	60	60	100	60	60	60	100	176	40	80	60	110	176	48	90	40	110					
70	90	90	60	60	101	60	60	60	101	177	40	80	60	111	177	40	80	40	89					
71	90	90	60	60	102	60	60	60	102	178	40	80	60	112	178	48	90	40	111					
72	90	90	60	60	103	60	60	60	103	179	40	80	60	113	179	40	80	40	90					
73	90	90	60	60	104	60	60	60	104	180	40	80	60	114	180	48	90	40	112					
74	90	90	60	60	105	60	60	60	105															
75	90	90	60	60	106	60	60	60	106															
76	90	90	60	60	107	60	60	60	107															
77	90	90	60	60	108	60	60	60	108															
78	90	90	60	60	109	60	60	60	109															
79	90	90	60	60	110	60	60	60	110															
80	90	90	60	60	111	60	60	60	111															
81	90	90	60	60	112	60	60	60	112															
82	90	90	60	60	113	60	60	60	113															
83	90	90	60	60	114	60	60	60	114															

List of Dividing Gears Supplied with Mach

		30		40		50		60		70		80		90										120
			31		41		51		61		71		81		91									
		32		42		52		62		72		82		92										
		33		43		53		63		73		83		93										
24				44		54		64		74		84		94										
		35		45		55		65		75		85		95										
26		36		46		56		66		76		86		97										
27		37		47		57		67		78		87		97										
		38		48		58		68		79		88												
		39		49		59		69		79		89												

TABLE 2. SPUR AND HELICAL GEAR CUTTER FEED AND FEED INDEX GEARS

#4

Tables and Diagrams For
Gould and Eberhardt 72" x 20" x 1 1/2" PD Gear Hobbing Machine
Spur and Helical Gear Cutter Feed Gears and Feed Index
and list of feeds obtainable

#13

For Worm Wheels see Infeed Plate on Machine

For Spur and Spiral Gears 0° to 36°

Feed = $\frac{\text{Driver} \times 2\text{nd Compd.}}{8 \times \text{Driven} \times 1\text{st Compd.}}$

Driven-D, Inter., 2nd Compound-C, 1st Compd.-B, Driver-A

L.H. Cutter use Feed Inter. Gear

Material	Feed	Driven D	2nd Cpd C	1st Cpd B	Driver A
Tool Steel	.01	90	24	75	24
Tough Steel	.02	80	40	75	24
Aver. Steel-Rough Cut	.03	60	60	75	36
Aver. Steel-Finish Cut	.04	60	51	75	24
Soft Steel-Rough Cut	.10	60	60	60	40
Soft Steel-Finish Cut	.04	60	60	75	24
Steeline-Rough Cut	.16	60	60	60	51
Steeline-Finish Cut	.08	60	60	75	30
Soft Ct.-Rough Cut	.15	60	60	45	54
Soft Ct.-Finish Cut	.06	60	60	75	36

For Spirals 36° to 45°

Feed = $\frac{4}{5}$ of Spur Gear Feed

D, C, B, A

Material	Feed	Driven D	2nd Cpd C	1st Cpd B	Driver A
Tool Steel					
Tough Steel	.016	96	40	75	24
Aver. Steel-Rough Cut	.024	60	60	75	40
Aver. Steel-Finish Cut	.023	80	40	75	30
Soft Steel-Rough Cut	.01	60	60	54	36
Soft Steel-Finish Cut	.032	60	54	75	24
Steeline-Rough Cut	.098	60	60	51	40
Steeline-Finish Cut	.04	60	60	75	24
Soft Ct.-Rough Cut	.12	60	60	60	51
Soft Ct.-Finish Cut	.048	60	51	40	36

For Spirals 45° to 60°

Feed = $\frac{2}{3}$ of Spur Gear Feed

D, C, B, A

Material	Feed	Driven D	2nd Cpd C	1st Cpd B	Driver A
Tool Steel					
Tough Steel	.0125	96	24	75	30
Aver. Steel-Rough Cut	.054	60	54	75	36
Aver. Steel-Finish Cut	.02	80	40	75	24
Soft Steel-Rough Cut	.065	60	60	75	30
Soft Steel-Finish Cut	.025	80	40	75	30
Steeline-Rough Cut	.08	80	60	54	36
Steeline-Finish Cut	.033	75	54	60	30
Soft Ct.-Rough Cut	.10	60	60	60	40
Soft Ct.-Finish Cut	.02	60	60	75	24

For Spirals 60° to 75°

Feed = $\frac{1}{2}$ of Spur Gear Feed

D, C, B, A

Material	Feed	Driven D	2nd Cpd C	1st Cpd B	Driver A
Tool Steel					
Tough Steel	.01	96	24	75	24
Aver. Steel-Rough Cut	.04	60	60	75	24
Aver. Steel-Finish Cut	.015	96	40	60	24
Soft Steel-Rough Cut	.05	60	60	75	30
Soft Steel-Finish Cut	.02	80	60	75	24
Steeline-Rough Cut	.06	60	60	45	36
Steeline-Finish Cut	.025	80	60	75	30
Soft Ct.-Rough Cut	.075	60	60	45	54
Soft Ct.-Finish Cut	.03	60	51	75	24

For Spirals 75° to Zero

Feed = $\frac{1}{3}$ of Spur Gear Feed

D, C, B, A

Material	Feed	Driven D	2nd Cpd C	1st Cpd B	Driver A
Tool Steel					
Tough Steel					
Aver. Steel-Rough Cut	.025	80	40	75	30
Aver. Steel-Finish Cut	.01	96	24	75	24
Soft Steel-Rough Cut	.033	75	54	60	30
Soft Steel-Finish Cut	.0125	96	24	75	30
Steeline-Rough Cut	.02	60	60	60	24
Steeline-Finish Cut	.016	75	40	45	30
Soft Ct.-Rough Cut	.025	60	60	45	30
Soft Ct.-Finish Cut	.02	80	40	75	24

List of Cutter Feed Gears supplied with machine

		30		40		50	51	60				80												
	24					54				75														
				25																				
		36											96											
									68															

INTERCHANGEABLE WITH LEAD GEARS.

TABLE 3. LEAD GEARS FOR HELICAL GEARS AND LIST OF LEAD CHANGE-GEARS

#6 #14

Tables and Diagrams for Gould and Eberhardt 72" × 20" × 1½ P.D. Gear Hobbing Machine

Table of Lead Gears for Helicals and List of Lead Change Gears

Angle of Gear		10°	12°	15°	18°	20°	23°	25°	26°/24°	30°	35°	40°	45°	50°	55°	60°	63°/26°	65°	70°	75°	80°
1-P.N.D.	Driver - A	30	24	30	30	24	30	24	40	30	30	30	36	24	40	36	60	36	36	36	30
	1st Compd - B	70	96	80	90	96	72	96	64	65	90	60	72	64	72	72	48	72	72	72	70
	2nd Compd - C	24	36	40	36	61	60	56	40	40	69	45	54	52	61	54	36	60	61	59	56
	Driven - D	91	68	61	61	70	67	52	79	58	63	55	60	40	65	49	79	52	51	48	52
1¼-P.N.D.	Driver - A	30	24	24	30	30	30	24	50	30	30	40	45	31	40	40	74	45	45	45	30
	1st Compd - B	56	96	96	90	96	72	96	64	65	60	64	72	68	72	64	52	72	72	72	63
	2nd Compd - C	28	45	36	45	61	60	70	36	50	40	45	54	52	61	54	40	60	61	59	79
	Driven - D	91	68	68	61	70	67	52	79	58	73	55	60	64	52	49	80	52	51	48	44
1½-P.N.D.	Driver - A	36	30	24	36	24	36	30	51	30	60	45	51	32	48	48	74	48	48	60	35
	1st Compd - B	70	80	80	80	70	72	90	68	65	60	64	68	80	72	60	52	64	64	64	63
	2nd Compd - C	30	36	36	40	61	60	42	43	60	40	48	54	52	61	54	40	60	61	59	79
	Driven - D	91	68	68	61	64	67	52	79	58	73	55	60	64	52	49	80	52	51	60	60
1¾-P.N.D.	Driver - A	48	24	36	30	24	30	36	56	70	70	70	56	63	49	60	70	56	56	49	79
	1st Compd - B	64	96	90	90	64	72	72	64	52	60	60	64	60	63	56	40	64	64	56	56
	2nd Compd - C	28	64	49	63	61	70	60	45	36	69	50	54	52	61	52	45	60	61	59	80
	Driven - D	91	68	68	61	80	67	52	79	87	73	55	60	64	52	60	79	52	51	48	80
2-P.N.D.	Driver - A	48	36	30	36	30	30	30	60	48	60	45	63	40	64	60	80	70	60	60	60
	1st Compd - B	80	80	96	72	70	72	72	48	65	48	60	60	80	63	49	60	56	60	48	63
	2nd Compd - C	56	20	56	48		50	36	56	50	40	60	60	79	61	54	48	60	61	59	79
	Driven - D	76	68	55	61	48	67	52	79	58	73	55	70	54	52	60	79	65	51	60	60
2¼-P.N.D.	Driver - A	63	40	36	40	61	45	36	45	72	50	63	54	60	56	74	60	61	59	79	79
	1st Compd - B	76	96	90	80	64	67	72	56	65	48	48	56	64	60	56	48	56	56	64	48
	2nd Compd - C	24	36	64	54	56	50	63	45	60	40	45	54	65	61	63	54	63	63	72	72
	Driven - D	80	80	68	61	70	60	52	79	58	73	55	60	50	52	49	65	52	51	48	63
2½-P.N.D.	Driver - A	80	70	56	40	61	50	36	63	50	75	60	65	60	60	60	75	60	61	72	80
	1st Compd - B	80	84	90	80	80	84	72	52	65	45	48	52	64	54	48	24	48	48	48	40
	2nd Compd - C	24	24	30	60	50	25	70	45	60	40	45	54	48	61	54	36	60	60	59	79
	Driven - D	76	96	68	61	70	67	52	79	58	73	55	60	50	52	49	79	52	51	60	74
2¾-P.N.D.	Driver - A	36	72	24	48	55	56	36	77	55	77	55	55	55	61	55	74	75	61	59	79
	1st Compd - B	63	56	80	60	80	60	72	56	65	63	48	56	40	63	40	65	40	40	56	40
	2nd Compd - C	35	28	77	55	61	50	70	45	60	60	60	54	77	77	54	77	55	55	55	55
	Driven - D	70	70	51	61	70	67	52	79	58	73	60	48	54	52	49	56	65	51	48	63
3-P.N.D.	Driver - A	84	75	36	60	60	69	84	60	72	60	72	54	72	60	60	72	65	65	72	60
	1st Compd - B	70	60	80	60	70	60	57	24	65	36	40	48	60	52	40	65	48	48	40	40
	2nd Compd - C	36	36	56	36	61	50	40	24	60	40	45	54	65	61	54	70	60	61	59	60
	Driven - D	91	68	51	61	48	67	60	96	58	73	55	60	40	52	49	40	52	51	52	63
3½-P.N.D.	Driver - A	98	49	49	63	49	63	60	70	60	80	80	70	65	70	70	56	70	70	75	60
	1st Compd - B	50	56	60	61	70	54	60	40	52	48	54	40	48	45	40	52	40	40	30	60
	2nd Compd - C	30	36	48	60	61	50	49	45	56	56	56	54	63	61	54	74	60	61	50	79
	Driven - D	91	68	68	75	56	67	52	79	58	73	60	60	50	52	49	40	52	51	58	36
4-P.N.D.	Driver - A	105	48	56	60	60	60	80	64	80	60	72	60	80	72	96	72	72	72	80	72
	1st Compd - B	75	72	60	80	60	45	60	40	52	36	30	36	50	45	36	24	36	36	40	32
	2nd Compd - C	56	80	48	48	61	50	56	45	60	48	45	54	65	61	54	48	60	61	59	72
	Driven - D	76	68	68	61	56	67	52	79	58	73	55	60	40	52	49	79	52	51	48	63
5-P.N.D.	Driver - A	125	60	72	60	75	65	75	80	80	75	65	65	80	75	72	75	75	75	80	60
	1st Compd - B	60	60	56	36	60	45	50	24	52	24	30	52	36	36	40	52	30	30	30	63
	2nd Compd - C	56	45	70	60	61	50	60	36	60	40	45	72	52	61	54	72	60	61	59	79
	Driven - D	76	68	68	61	56	67	52	79	58	73	55	60	40	52	49	96	52	51	48	63
6-P.N.D.	Driver - A	70	60	60	60	60	72	60	80	96	72	90	72	72	72	72	96	90	90	90	80
	1st Compd - B	50	60	70	30	56	36	60	24	52	24	28	40	70	54	56	48	60	60	56	32
	2nd Compd - C	56	56	63	36	61	50	60	36	72	48	45	72	65	61	54	72	60	61	59	79
	Driven - D	76	68	51	61	70	67	52	79	58	73	55	60	80	52	49	80	52	51	48	52
8-P.N.D.	Driver - A	60	60	64	72	80	80	70	96	64	96	65	90	96	96	96	96	96	96	96	96
	1st Compd - B	50	40	40	36	40	30	40	32	52	32	44	60	40	48	48	72	60	60	59	79
	2nd Compd - C	56	48	56	48	61	50	60	45	60	80	45	54	72	72	54	96	60	61	59	79
	Driven - D	76	68	68	61	70	67	52	79	58	73	55	60	80	52	49	65	52	51	48	63

List of Lead Change Gears supplied with machine

	30	23	50	29	70	78	80	91			
			51	61	71	79	85	97			
			52	62	72	80	86	98	INTERCHANGEABLE		
			53	63	73	81	87	99	WITH FEED GEARS		
*24			54	64	74	82	88	100			
			55	65	75	83	89				
	36	25	56	66	76	84	90				
			57	67	77	85	91				
		29	58	69	79	87					

TABLE 4. ROTATIVE AND CIRCUMFERENTIAL SPEEDS OF CUTTERS

#5 #15

Tables and Diagrams for Gould and Eberhardt 72" × 20" × 1½ P.D. Gear Hobbing Machine

Rotative and Circumferential Speeds of Cutters

Nominal Diametral Pitch	Cutter Dia.	Cutting Speeds in Feet per Minute: 45	50	55	60	70	80	90	100
		Revolutions of Cutter per Minute							
1	10¼	16	18	20	22	26	30	33	37
1½	8¼	21	23	25	28	33	37	42	46
1½	7½	23	25	28	30	35	40	46	51
1½	7¼	24	26	29	32	37	42	47	52
2	5¾	31	34	37	40	47	54	60	68
2¼	5¼	33	37	40	44	51	59	66	73
2½	5	35	38	42	46	53	61	69	76
2¾	4¾	36	40	45	49	56	65	72	80
3	4½	38	43	47	51	60	68	77	85
3½	4⅛	42	46	51	56	65	74	83	93
4	3⅛	44	49	54	59	69	79	90	99
5	3½	49	55	60	65	77	87	98	109
6	3¼	53	59	65	71	82	94	106	118
6⅛	2⅞	60	67	73	80	93	106	119	133
7	3	57	64	70	76	89	102	114	127
8	2⅞	60	67	73	80	93	106	119	133
9									
10									
12									

Preferred speeds for different classes of material.

	Ft. Per Min.		Ft. Per Min.	Average
Tool Steel	40	To	50	45
Tough Steel	40	"	60	45
Aver. Steel - Rough Cut	50	"	60	55
Aver. Steel - Finish Cut	50	"	70	60
Soft Steel - Rough Cut	60	"	80	60
Soft Steel - Finish Cut	60	"	80	70
Steeline - Rough Cut	50	"	70	60
Steeline - Finish Cut	50	"	70	60
Soft C.I. - Rough Cut	60	"	90	80
Soft C.I. - Finish Cut	60	"	90	80

FINISH

indicated in Fig. 4 for spur gears, and in Fig. 3 for helical gears. Make sure the index and lead gears are properly set before feed stop and start plunger *E*, Fig. 12, is engaged.

11. The feed to the cutter is now engaged by raising the feed stop and start plunger *E* at the right-hand side of the machine. Take care to have lever *C* in its proper position for feeding the cutter-slide. The feed stop and start plunger *E* should not be raised with lever *C* in the position for the stanchion traverse (except as stated later for worm-wheel hobbing) until the bolts on the stanchion are loosened.

12. The feed trip-dog *G* at the left of the machine is next adjusted to stop the machine when the teeth in the gear blank have been completed. The feed trip-rod operates a clutch in the pulley and stops the entire machine. To again connect the clutch, lever *B* is operated to the left and the belt moved by hand until the clutch teeth engage. Do not try to throw the clutch lever *B* into engagement while pulley is revolving rapidly.

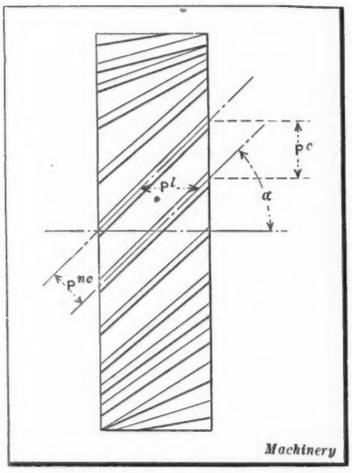

Fig. 7. Diagram explaining Nomenclature

Instructions for Cutting Spur Gears

The following gives instructions for setting the hob, cutter-arbor, index dividing gears and feed change-gears for cutting spur gears. For example, suppose it is required to cut a "steeline" spur gear of 90 teeth and 1½ nominal diametral pitch, with a right-hand hob having an angle $B = 4$ degrees.

1. Refer to Table 1 for index dividing gears; find for 90 teeth the dividing change-gears and arrange as indicated in Figs. 1 and 4.

2. Refer to Table 2 for feed change-gears and find for a steeline spur gear the feed change-gears and arrange as indicated in Figs. 1 and 4.

3. Throw lever *F*, Fig. 1, into spur gear position.

4. Refer to Table 4 for cutter speeds, and assume that the cutter diameter corresponds to that given in the table for 1½ nominal diametral pitch, namely, 7½ inches; assume that 60 feet per minute is the desired cutting speed. Then the hob should make 30 revolutions per minute. Now refer to the cutter-speed index-gear tag located to the left of the cutter-speed change-gear studs and select the change-gears that will give revolutions of the cutter corresponding closely to 30 revolutions. In this instance, we select change-gear *A* with 24 teeth and change-gear *B* with 36 teeth. For convenience, the cutter-speed gear table is given below:

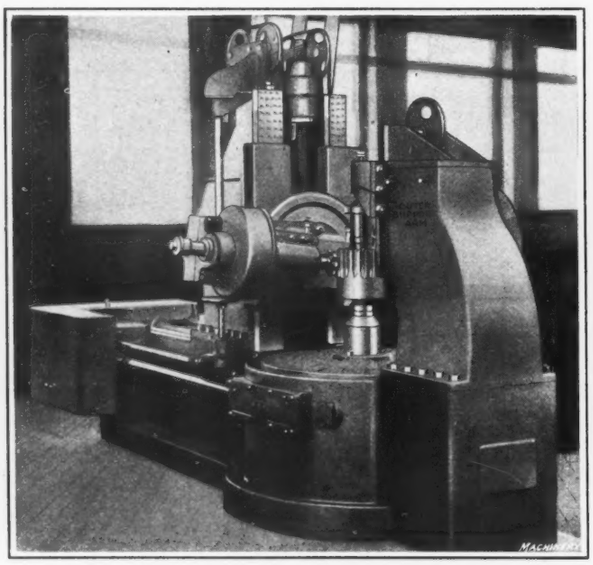

Fig. 8. General View of Gould & Eberhardt 72- by 20-inch Automatic Spur and Helical Gear Hobbing Machine taken from Front of Machine

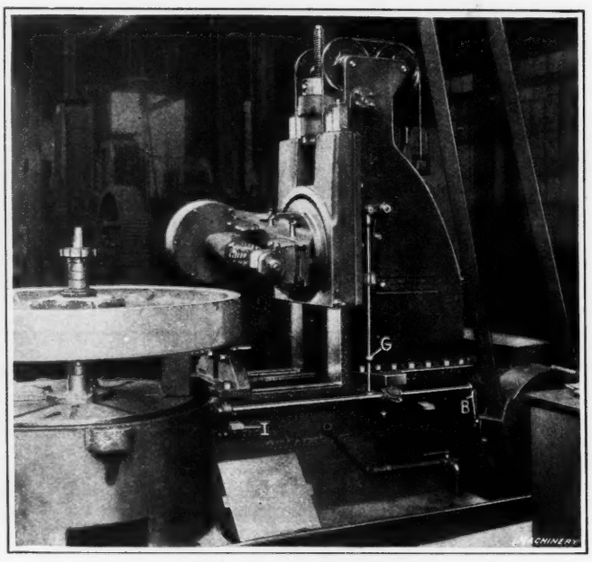

Fig. 9. View of Machine shown in Fig. 8 taken from Side and showing Location of Pulley Clutch Lever B, Feed Trip-dog G and In-feed Trip-dog I

Nomenclature (See Fig. 7)

N = number of teeth to be cut;
P^d = diametral pitch of gear;
P^{nd} = normal diametral pitch of gear;
P^c = circular pitch of gear;
P^{nc} = normal circular pitch of gear;
P^l = linear pitch;
α = angle of helix with axis;
B = angle marked on helical cutter;
α' = angle to set cutter;
a = addendum of tooth;
T = number of threads in hob;
E = difference between 1 and the result of proof formula;
V = ratio of lead gearing.

Fig. 10. Method of using Hob-setting Device on 84-inch Gould & Eberhardt Automatic Gear-hobbing Machine

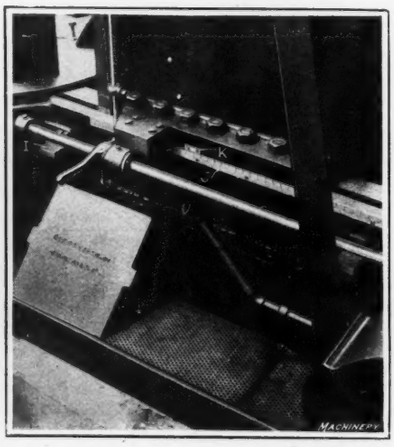

Fig. 11. View of Machine showing Positions of In-feed Trip-dog I, Vernier Scale J and Vernier K

Cutter Speed Table
Gears for Cutter Speeds

R.P.M.	Driver A	Driven B
16	16	44
19	18	42
22	20	40
26	22	38
30	24	36
35	26	34
41	29	31
48	31	29
57	34	26
68	36	24

5. Refer to the third column in Fig. 4 for the position of the cutter reverse knob.

6. Refer to the fourth column in Fig. 4 for the position of the swiveling cutter-head and hob, and also for the direction of rotation of the work-table and hob. In this case the swiveling cutter-head must be set on the left side, making an angle with the plane of the work-table that is equivalent to the angle of the thread of the hob and is generally found stamped on the end of the hob. Angle B in this case is 4 degrees.

7. Set cutter-feed trip-dog G, Fig. 12, so that the cutter feed will be disengaged when the gear has been cut through.

Instructions for Cutting Worm-gears

In hobbing worm-wheels, the hob cutter should be an exact duplicate of the worm except in outside diameter. The hob is set with its axis perpendicular to the axis of the worm-wheel blank and then fed toward the blank until the full depth of the tooth is reached. The method of cutting worm-gears by the above process is the same as employed for spur gears with the following exceptions:

1. The swiveling cutter-head must be in a horizontal position so that the axis of the hob will be perpendicular to the axis of the worm-wheel blank, instead of occupying the position required by Step 6 under the spur gear instructions.

2. To operate the stanchion feed, disengage the vertical feed of the hob cutter by throwing lever C into the stanchion traverse position.

3. Throw lever F, Figs. 1 and 12, into spur gear position.

4. The stanchion feed is engaged by raising the feed stop and start plunger E. Note that the stanchion binding bolts must be loose when feeding the stanchion.

5. To feed toward the work, select feed per revolutions as dictated by best judgment for the material to be cut and then approximate that as closely as possible, selecting the change-gears from the "in-feed plate" tag located to the left of the driven feed gear on the feed-gear side of the machine.

Worm-gear Cutter Feed Gear

In-feed per Revolution of Blank	Driver A	1st Comp. B	2d Comp. C	Driven D
0.0030	24	24	96	97
0.0040	24	24	96	75
0.0052	24	30	96	75
0.0067	24	48	96	90
0.0085	24	51	96	75
0.0105	24	63	96	75
0.0127	24	60	96	60
0.0152	24	57	75	60

6. Set stanchion trip-dog I, Figs. 9, 11 and 12, to automatically stop stanchion feed at the proper center distance.

7. A scale and vernier is provided at J, Fig. 11, to determine the center distance between the work and arbors. It should be recalled that feeding the hob toward the worm-wheel blank in this manner does not form a theoretically correct tooth, because the theoretical helix angle is constantly changing, due to the changing center distances. Since the helix angle is constantly changing, the hob cuts away portions of the tooth that are necessary to give perfect contact with the worm. Theoretically correct worm-gears may be generated with a fly cutter or with a straight or taper hob, preferably a taper hob, fed in a plane perpendicular to the axis of the worm-wheel blank. For a complete description of methods of cutting worm-wheels, see Chapter X of "Spiral and Worm Gearing," published by The Industrial Press, New York City. When proper hobs are not available and emergency requires prompt cutting of a worm-wheel, an approximation may be cut by using the ordinary spur gear hob, provided it has the proper rack tooth section. To use the ordinary spur gear hob, set the machine the same as usual for cutting worm-gears, but the swiveling cutter-head must be set with relation to the axis of the work so that the helix of the hob is parallel with the helix angle of the worm measured at the pitch line. For example, assume the helix angle of the worm measured at the pitch line $= \alpha = 30$ degrees and the helix angle of the spur gear hob $= B = 4$ degrees; then the swiveling cutter-head should be set at an angle with the work-table equal to $\alpha' = \alpha - B = 30 - 4 = 26$ degrees.

Instructions for Cutting Helical Gears

The following gives instructions for setting the hob, cutter-arbor, index dividing gears, feed change-gears and lead change-gears for cutting helical gears. For example, suppose it is required to cut a right-hand 30-degree steel helical gear of 90 teeth and 1½ normal diametral pitch, with a right-hand hob having an angle $B = 4$ degrees.

1. Select and arrange the index dividing gears the same as for spur gears, Step 1.

2. Select and arrange the feed change-gears the same as for spur gears, Step 2, but base feed on steel instead of "steeline," and also select a feed corresponding to the proper spiral angle.

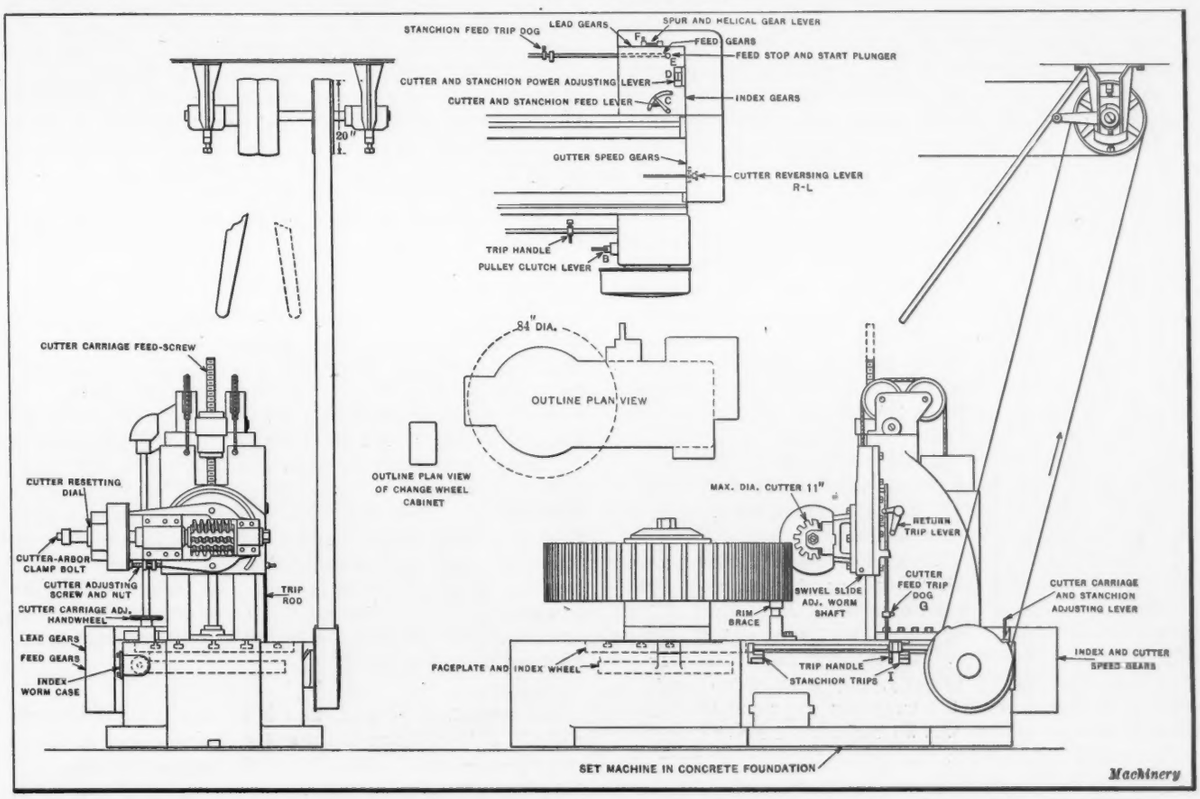

Fig. 12. Front, Side and Plan Views of Machine showing Locations of Pulley Clutch Lever B, Cutter and Stanchion Feed Lever C, Cutter and Stanchion Control Lever D, Feed Stop and Start Plunger E, Spur and Helical Gear Lever F, Cutter Feed Trip-dog G, Stanchion Trips I, and Cutter Reversing Knob RL

3. Refer to Table 3 of lead change-gears, and select for 1½ normal diametral pitch, 30-degree spiral gear angle the lead change-gears and arrange as shown in Fig. 3.

4. Select and arrange the cutter speeds the same as for spur gears, Step 4.

5. Throw lever *F*, Figs. 2 and 12, into helical gear position.

6. To set cutter reverse knob, refer to Fig. 3, third column from left.

7. To set swiveling cutter-head, refer to Fig. 3, fourth column from left, where will also be found instructions for direction of rotation of work-table and hob. In this case the swiveling cutter-head must be set on the right side, making an angle with the plane of the work-table which is equivalent to the spiral angle of the gear = a less the thread angle of the hob = B.

8. To cut a left-hand helical gear with the same hob, the swiveling cutter-head must be set on the left side, making an angle with the plane of the work-table which is equivalent to the spiral angle of the gear = a plus the thread angle of the hob = B.

* * *

CRITICIZING THE DESIGNER

BY DONALD A. HAMPSON [1]

It seems to be one of the fundamental traits of human nature to criticize, and men engaged in the machine business are no exception to the general rule. Criticism is all right in its place; indeed, it is often the whip that spurs us on to better efforts and finally brings success out of our failures. To criticize poor workmanship is but just to all concerned; to criticize a person's best efforts without qualifying the remarks or considering the obstacles that it may have been necessary to overcome is certainly unjust. In line with the latter the designer of tools and machinery comes in for his full share of unfairness. Every day we hear someone say in criticism of some piece of machinery, "Why didn't he do it this way?" or, "If he had only made a different kind of latch, a man could get the pieces in and out of the jig," and the remark is usually ended with, "I would have made it so and so at the start and avoided that trouble." Now the truth is the designer is up against more than he is given credit for. The man who can see in his mind the completed device while making the first pencil marks is exercising his brain to a far greater extent than the man who calmly suggests a minor change after he has seen the other's work. And yet unconsciously we put the critic down as a smart man and the designer as a sort of botch. When a piece is completed, the preliminary work does not show, the conditions under which the designer labored are not apparent, the lack of data and time given him and the absence of similar work in the same line with which to make a start are not considered. A typical case of criticism will show just these points. It is one that is familiar to designers who develop for inventors. An inventor conceived the idea of a machine for wrapping, folding and addressing magazines, printing the names from a celluloid stencil that was to be handled by means of suction applied at definite points and set to suit the particular issue. The one thing really "invented" was the air handling of a stencil of a given material. With this as a basis, the inventor went to a designer with instructions to lay out the machine—nothing else. The designer had little to work from outside of these meager instructions and the knowledge picked up, by good luck, from the failures of several other machines built to do practically the same work. In the course of six months, the blueprints were ready to go to the shop.

The machine, when built, was a model of good designing, and if it had worked as well "loaded" as when running "light," it would have been a complete success. Also it would have surprised any man of experience in the special machinery field; but not the inventor. He could not understand why his stencils did not handle properly, why a magazine would be skipped sometimes, why the wrapping paper got tangled up. He was sure his scheme was all right, but he was afraid the designer had bungled the arrangement. The designer suggested certain changes after seeing the machine run which, with many others, were tried out, and in the course of two years the machine was ready for the market. Today that machine is the best in the field, taken all around, and does its work to a purchaser's satisfaction. But an examination will show that the celluloid stencil has given place to a steel one and the air handling to mechanical means. Nothing remains of the original machine but the lay-out and the frame and drive; the designer's work is practically all there and the inventor's is not. Many details, of course, had to be changed entirely, and a healthy scrap pile was acquired in the changing. But the unfair part is that the inventor gazes fondly at the machine as he shows it to a friend and says: "It's all mine—most of Smith's work had to be thrown away—mine, that I and the boys in the shop built out of the wreck. You know, a thing that looks good on paper doesn't always work out that way." Yes, and even the boys in the shop had been heard to criticize Smith for the feed that clogged and for numberless other constructions that would have been better another way. However, a remarkable thing about Smith's work was its correctness, and the shopmen cannot fail to admire secretly the man who could design a machine of such magnitude and not have a single interference anywhere or leave off a couple of bosses.

Smith's is just another instance of a job well done for which no credit is given, but on which criticism is freely bestowed. He represents a class whose only reward may be the consciousness of having done well and of knowing that it is far easier to criticize than to create; they are the real mechanical pioneers.

* * *

LOCOMOTIVE FEEDWATER HEATING [1]

Heating the feedwater of a locomotive by heat otherwise wasted is a fairly general practice in all the more progressive European countries, but experiments along these lines have been spasmodic in this country up to a recent period. By investigating the general distribution of heat in a locomotive, it was found that 65.2 per cent of the total heat of the coal is discharged in the exhaust steam, mostly in the form of latent heat. The exhaust steam, of course, does some work in producing draft and cannot be considered as a total loss, but calculations can be made which will easily show that it is largely loss, and that a small proportion of this heat could perform the work of producing draft satisfactorily. It is evident that if any part of this heat is reclaimed and returned to the boiler, it will allow a reduction of the same amount in the quantity of heat supplied by the coal to produce the same cylinder horsepower. The most natural and feasible method of collecting part of this waste and delivering it into the boiler is by using as much of it as is practicable to heat the feedwater before it enters the boiler.

Another feature of the subject is the effect of feedwater heating on the boiler efficiency. As the rate of combustion is decreased the boiler efficiency increases, and when a feedwater heater is applied to a locomotive it allows the production of the desired amount of steam with a reduction in the amount of coal fired, which increases the boiler efficiency. In the case of a large passenger locomotive, a reduction of ten pounds of coal per square foot of grate area per hour gives an increase in boiler efficiency of about 3 per cent, which should be credited to the heater. A rule of thumb that has long been used in stationary and marine practice is that for each 11 degrees that the feedwater is heated by a source otherwise wasted, there will be a 1 per cent saving in fuel. Such experiments as have been made on locomotives indicate that this amount is conservative and can be easily attained. When the maximum capacity of the locomotive is being used, savings considerably in excess of this are indicated. It appears that an economy of at least 10 per cent can be reasonably expected even at light rates of working.

* * *

The present price of gasoline in Sweden is about 85 cents a gallon. This indicates the scarcity of motor fuel in the neutral countries and incidentally in the Central Empires.

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[1] Abstract of a paper read before the Minnesota section of the A. S. M. E. on March 10, 1917, by George M. Basford, New York City

TAPS AND TAPPING EQUIPMENT[1]

MODERN DEVELOPMENTS IN DESIGN OF TAPS AND TAPPING APPLIANCES—IMPORTANT FACTORS AFFECTING ACTION OF TAPS—VARIOUS TYPES OF TAP-HOLDING CHUCKS

BY FRANKLIN D. JONES[2]

THE relation between taps and other tools that may be used for cutting screw threads in holes is similar to the relation between dies and the various classes of equipment that are adapted for cutting external threads. The principal points of similarity between taps and dies pertain, first, to the extent of their application, and, second, to the factors that govern their use. Taps are employed for most internal thread cutting operations, just as most external threads are cut with dies, but the extent to which taps are applied for internal threading gradually diminishes as the diameter of the threaded part increases above a certain size, which applies also to the use of dies in cutting external threads. While practically all small holes that are to receive machine screws, studs, bolts, etc., are threaded by means of taps, tools of this class are not suitable for cutting a great many of the larger screw threads. It is impracticable, of course, to draw a definite dividing line on the basis of diameter alone, since there are frequently other important conditions that affect the problem. Whether or not taps may be used to advantage often depends upon: (1) number of parts requiring screw threads or amount of work; (2) diameter and pitch of thread; (3) relation between thread-cutting and other machining operations. If cutting the thread is the principal or only operation, and especially if the parts are required in large numbers, a tap might be used even for quite large diameters in order to cut the threads quickly. Pipe fittings, which have comparatively fine threads, are an example.

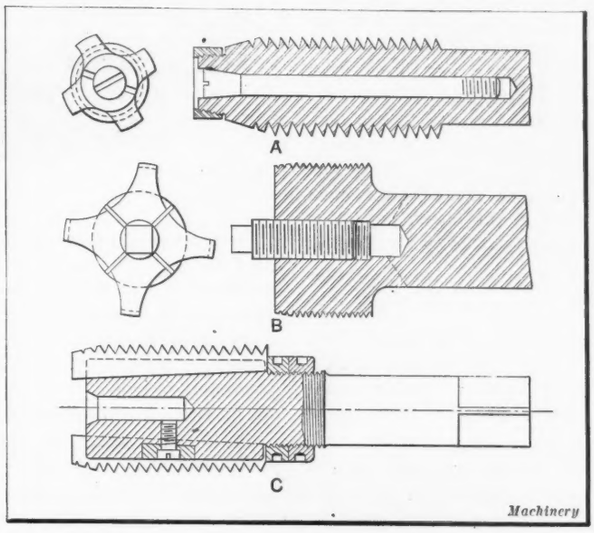

Fig. 1. Taps that can be adjusted to compensate for Wear or for varying Size

The equipment that is available in a shop is another important point, since there is often a close relationship between investment and method. No experienced manufacturer or shop superintendent would consider making or buying high-priced taps for a certain job unless the number of parts to be tapped were large enough to warrant the expenditure. For cutting a few threads, the engine lathe might be more economical and often preferable regardless of the quantity, either because of the diameter of the thread, pitch, or relation to other machined surfaces. In one sense, every tap is a special tool, since it can only be used for cutting one pitch of thread, and is usually intended for only one diameter, although in some cases a slight adjustment may be made above or below the standard size. For that reason, we find that taps, as well as dies, are used principally on machine tools that are designed more especially for producing duplicate parts in quantity than for handling a large variety of work. For instance, practically all the internal thread cutting on turret lathes or automatic screw machines is done by taps, just as most of the external thread cutting is done by dies.

Non-collapsing Taps

The fixed or non-collapsing tap is the most important class if judged by the extent to which it is used. Non-collapsing taps may be divided into three general types, as follows: (1) solid taps, or those formed of one solid piece of steel; (2) adjustable taps, which usually have inserted blades that can be adjusted a certain amount radially; and (3) inserted-blade non-adjustable taps. All these taps may also be further classified according to whether they cut straight or tapering screw threads, and also with reference to their intended use. For example, there are hand taps for use when tapping holes by hand; tapper taps for tapping nuts in regular tapping machines; staybolt taps for tapping the inner and outer sheets of steam boiler fireboxes; pipe taps for tapping holes for standard pipe sizes; screw machine taps for use on automatic screw machines; and various other classes.

While solid taps are the cheapest and are used the most, a great many adjustable taps are found in modern shops and are applied especially when accuracy is essential. A solid tap is liable to slight changes in diameter due to hardening, and there is, of course, some reduction in diameter due to wear. By using a tap that is adjustable, a standard size may readily be maintained. The adjustable tap may be made from a solid piece of steel and may be split so as to permit expanding it sufficiently to compensate for wear, or it may have inserted blades or chasers arranged for radial adjustment. With an adjustable tap of the inserted-chaser type, the body of the tap may be made of a comparatively low-priced material, and this main part of the tap may be used indefinitely, the chasers being replaced when necessary.

Examples of Adjustable Tap Design

Several different forms of adjustable taps are illustrated in Fig. 1. A one-piece split type is shown at *A*. The tap is split through the center, and it is expanded by the conical-headed screw shown. A nut engaging the tapering thread at the end of the tap serves to hold the two sections firmly together. One serious defect of a tap of this kind is that the tap is not expanded uniformly, and for that reason does not cut an accurate thread; the inaccuracy, however, would be very slight for adjustments that might be necessary in order to compensate for wear and maintain a standard size. Another form of split adjustable tap is illustrated at *B*. The tap is split through the center of each flute and it is expanded by the screw shown, which is slightly tapering. The smaller taps of this kind have slotted screws for screwdriver adjustment. While these types are superior to the solid form for tapping large numbers of duplicate parts to a given size within close limits, the inserted-blade type of tap is preferable and is used considerably, especially on accurate work. When extreme accuracy is necessary, it is common practice to use a hand-operated inserted-blade

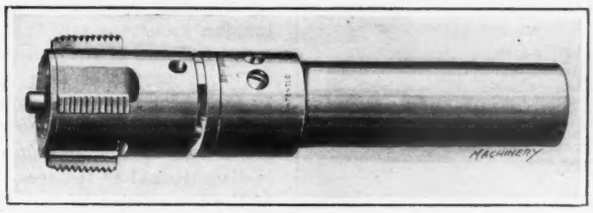

Fig. 2. "Namco" Collapsing Tap

[1] For additional information on this subject, see "Screw Thread Cutting with Dies," in the October number of MACHINERY.

[2] Associate Editor of MACHINERY

tap for finishing holes previously tapped on a machine. Taps of this kind should be so designed that the blades are held rigidly to the body of the tap and preferably in such a way that the means for locking or adjusting the blade does not interfere with the use of the tap.

The adjustable tap shown at *C* is so designed that it can pass clear through a hole or tap to the bottom of a "blind" or closed hole. The blades are located in longitudinal grooves or slots which taper on the bottom, so that any change in the lengthwise position of the blade increases or decreases the tap diameter. The tap blades are securely held in position by binder plates in the center and thrust and locking nuts at the inner ends. Each blade has a small groove in one side, which forms a shoulder and a bearing surface for one side of the binder plate which is tightened by a screw. When the binder plates are tightened and the nuts at the inner ends are screwed tightly against the ends of the blade, the latter are held rigidly in their slot. This tap is made by the Pratt & Whitney Co., Hartford, Conn.

Removal of Non-collapsing Taps from Tapped Holes

The removal of a solid or non-collapsing tap from a hole in which a thread has been cut is usually done by backing the tap out of the hole, but in some cases the tap either passes completely through the tapped hole or else the work passes over the tap. Taps may be backed out of holes either by reversing the rotation of the spindle which holds and drives the tap or by reversing the part being tapped when the tap has advanced in the hole to whatever distance may be required. When the machine spindle is reversed this may be effected either by means of the regular driving mechanism of the machine or by a special attachment applied to the tap driving spindle. If the tap remains stationary while tapping, as on turret lathes and many automatic screw machines, the work-spindle reverses for backing out the tap.

Another method of removing a tap that is common in screw machine practice does not require a reversal either of the tap or of the part being tapped. When cutting the thread, the tap revolves in the same direction as the work, but at a slower speed; consequently the work tends to screw itself onto the tap just as though the tap were stationary and the work were revolving at a speed equal to the difference between the speed of the tap-spindle and the work-spindle. The opposite effect is obtained by revolving the tap faster than the work, which causes it to back out of the hole at a rate equal to the difference between the tap-spindle and work-spindle speeds. (This same method is applied to dies). These changes of speed are, of course, controlled automatically.

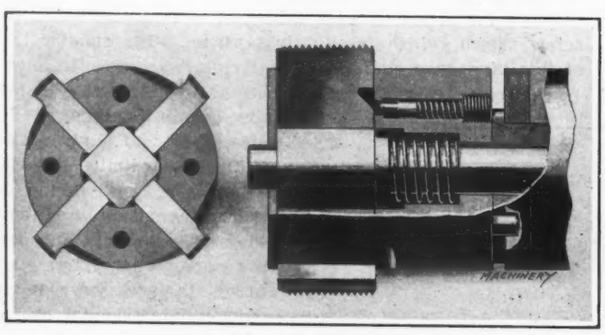

Fig. 3. Mechanism of "Namco" Collapsing Tap

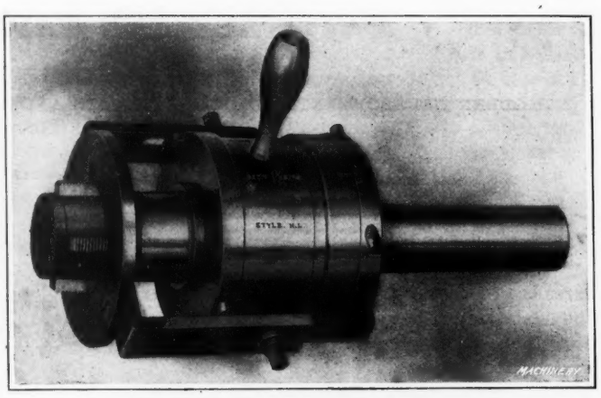

Fig. 4. Geometric Collapsing Tap

For some tapping operations it is desirable to screw the tap clear through the tapped hole. There are three conditions under which this general method may be applied: If the tapping is being done on a vertical drilling machine and there is a clearance space beneath the tapped hole which is large enough to receive the tap, the latter is sometimes screwed completely through the hole and is then replaced in the spindle driving chuck for tapping the next hole. The chuck, in this case, is ordinarily in the form of a socket that fits the tap shank, so that the tap is free to fall as soon as it clears the thread formed in the work. When tapping small parts, such as nuts, another common method of removing the work without screwing it back over the tap is to allow successive parts tapped to pass onto the tap shank; when the shank is full the tap is taken out of the chuck and the work removed. To avoid removing the tap periodically in order to take off tapped parts such as nuts, an ingenious form of tap has been devised which has a curved shank and is so mounted in the tapping machine that parts like nuts pass over the shank so that the tapping can be done continuously. The practical application of these methods will be considered more in detail later in connection with tapping machines and attachments.

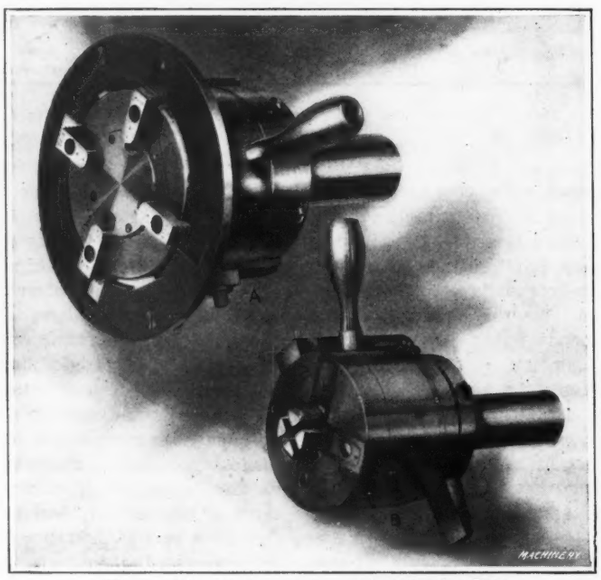

Fig. 5. Other Designs of Geometric Collapsing Taps

Advantages of Collapsing Taps and Variations in Design

The advantages of collapsing taps, as compared with the solid or non-collapsing type for machine tapping, are similar to the advantages of self-opening dies in contrast with the non-opening type. When a solid tap is removed by reversing either the tap or work, the threads cut by the tap are often injured by the chips which wedge in between the tool and the finished thread. The time wasted while the tap is backing out often greatly reduces the rate of production, and the power at the instant of reversal, as well as the strain on the machine used for tapping, may be considerable, especially when tapping comparatively large holes in tough material. On the other hand, solid taps cost less and are applicable for tapping numerous studs, screws and bolt holes that are too small for taps of the collapsible type.

The collapsing of taps may be done either automatically by the engagement of a collar, gage-plate, or lever on the tap with the surface of the work or a fixed stop; the collapsing action may also occur soon after the travel of the turret-slide is discontinued as the result of relative motion between parts of the tap similar to that which occurs when a stop is used. Collapsible taps are similar in principle to self-opening dies,

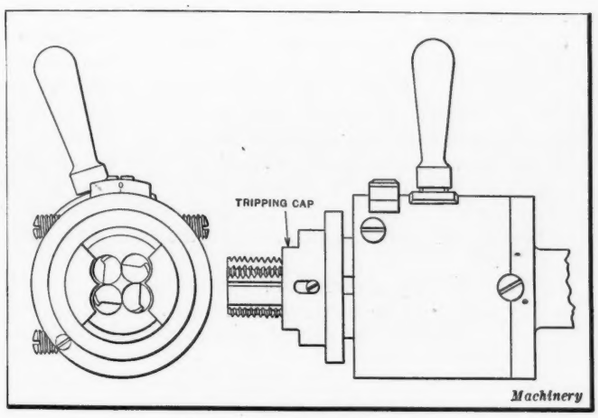

Fig. 6. M. E. C. Collapsing Tap

except that the action is reversed, the tap chasers moving inward in a radial direction instead of outward.

The collapsing tap illustrated in Fig. 2 is of the type that collapses soon after the turret stops. The chasers are withdrawn from the thread in practically the same way that a gear would be thrown out of mesh. When the forward movement of the turret stops, the tap continues to cut until the continued advance due to the action of the chasers in the tapped hole causes the driving pins to disengage; the chasers then begin to revolve with the work and are at the same time automatically withdrawn from engagement with the thread. When the chasers are in position for cutting they are supported by the corners of a central stationary core piece. As soon as the driving pins are disengaged and that part of the tap carrying the chasers begins to turn around with the piece being tapped, the chasers move around opposite the flat sides of the central core so that they naturally disengage themselves from the work. The small conical pointed plunger at the rear of each chaser (see Fig. 3) is simply a safety device to prevent the chasers from dropping back into contact with the thread. The end view shows the chasers in the collapsed position.

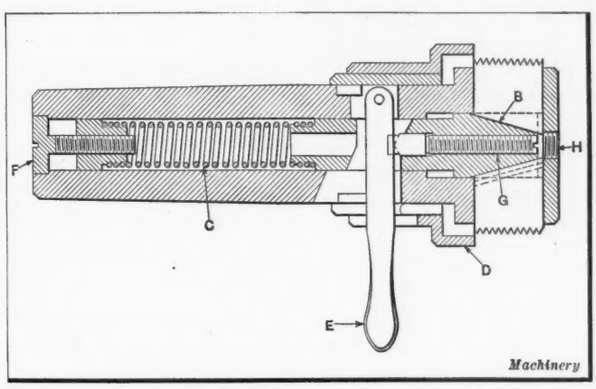

Fig. 7. Victor Collapsing Tap

An important feature of this tap is the fact that the tap body and shank will pass through the tapped hole, so that the tap can be used for tapping exceptionally long holes or holes that are only slightly smaller than the diameter of an opening through which the tap must be inserted to reach its work. The tap may be adjusted for cutting either tight or loose fitting threads by simply turning two binding screws and revolving the square core in either direction. The adjustments for the maximum or minimum diameters is shown by a graduated scale on the hub of the tap. A "Namco" tap of the outside trip type is so arranged that when the tap has entered the hole to the required depth, the outer tripping ring strikes the face of the work, thus causing the chasers to be collapsed. The tap is reset by means of a lever. This tap is particularly adapted for pipe threads or short straight threads. The "Namco" tap is made by the National Acme Co., Cleveland, Ohio.

One design of collapsing tap made by the Geometric Tool Co., New Haven, Conn., is shown in Fig. 4. This particular tap (Class NL) is made in sizes varying from 1 to 12 inches. The tap may be attached to a revolving spindle or to a turret. An adjustable gage controls the collapsing action by coming into contact with the work. The chasers are expanded by means of the handle shown projecting from one side of the tap body. Slight adjustments to compensate for wear may be made by means of micrometer adjusting screws. Another Geometric tap of a type (Class P) intended especially for tapping shallow holes and threads of fine pitch or flush to the bottom of a hole is shown at *A*, Fig. 5. This particular style of tap is furnished for cutting standard pipe threads from 4 to 10 inches, inclusive, and for tapping actual diameters varying from 4½ to 11 inches when the threads are not coarser than eight per inch, and the depth of the hole does not exceed 1½ inch. It will be understood that these taps are subject to more or less variation in design because of different working conditions. This tap has an end plate trip, as the illustration shows. The lever type of trip applied to the tap shown at *B* in Fig. 5 is particularly suited for certain classes of work. An adjustable screw-stop attached to the cross-slide of the machine engages the tripping lever and controls the point at which the collapsing action occurs. The Geometric collapsing tap may be fitted with a roughing and finishing attachment similar to that employed on the self-opening die-head, when tapping exceptionally accurate work. The tap chasers are adjusted outward for taking a light finishing cut by turning a small lever. None of the taps illustrated are equipped with this attachment.

A collapsible tap having chasers that operate with a rolling action is shown in Fig. 6. The four chasers are in the form of round bars except at the outer ends, where they are cut away to form clearance spaces in front of the teeth. Each chaser bar has a lug that engages a radial slot in a chaser controlling ring or collar within the tap body. When this controlling ring is turned in one direction the chasers roll so as to move the cutting teeth inward as when collapsing the tap. By turning the ring in the opposite direction the chasers are returned to the working position and size. The controlling collar is held in place by a suitable stop while the tap is cutting. When the tap has entered the hole to the required depth, the tripping cap comes into contact with the work, and as the tap continues to advance, the controlling collar is disengaged. A spring then turns the collar quickly and withdraws the chasers. The tap is reset to the working position by means of the hand-lever shown projecting from the side. The distance that the chasers project beyond the tripping cap, or the depth to which a hole is tapped, is regulated by an adjustable screw in the shank of the tap, which serves to move the chasers in or out. This tap is the product of the Manufacturers Equipment Co., Chicago, Ill.

The sectional view, Fig. 7, illustrates the arrangement of collapsible taps made by the Victor Tool Co., Waynesboro, Pa., for diameters of 2 inches and larger. The chasers, which are

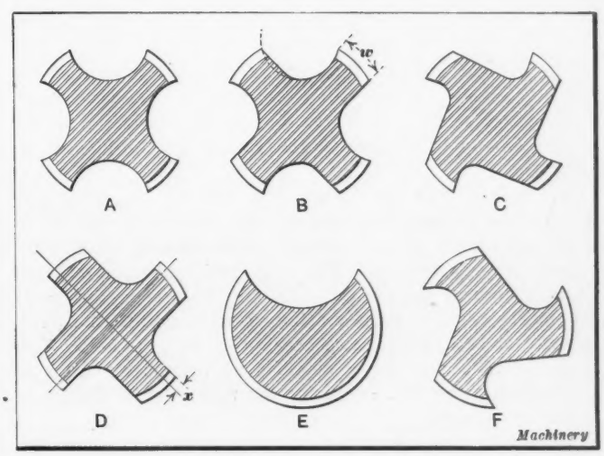

Fig. 8. Different Forms of Tap Flutes

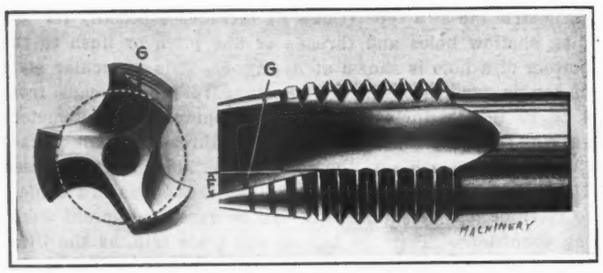

Fig. 9. "Gun" Tap having Cutting Edges on Chamfered End ground at an Angle to Axis for deflecting Chips and causing them to curl out ahead of Tap

inserted in radial slots in the body of the tap, bear against a hardened steel plunger or central plug *B*. This plunger is ground to an angle of 14½ degrees from the axis (29 degrees included angle) and the inner ends of the chasers are beveled to correspond. This plunger is attached to a closely wound tension spring *C*, which is elongated when the tap is set for cutting. The depth at which the tap collapses automatically is regulated by the trip-collar *D*, which can be adjusted for varying the tripping position. When this trip-collar strikes the face of the part being tapped, a latch is forced to release the tripping lever *E*, and then the tension spring immediately draws the plunger *B* back, thus permitting the chasers to recede along the angular surface of the plunger. The tap is reset in the cutting position by moving lever *E* forward to the position shown in the illustration, which forces the chasers outward and locks them in position. The tension on the spring may be regulated by the screw *F* at the rear of the tap shank. The size of the tap may be varied by means of a hardened set-screw *G* in the front end of plunger *B*. This screw has a very fine thread, so that minute adjustments may be obtained, and it is protected by the safety screw *H*. Collapsible taps that are less than 2 inches in diameter are similar to the design described except that the adjustment for size is secured by changing the position of a threaded collar.

Form of Tap Flutes or Cutting Faces

The location of the front cutting faces of taps, relative to the axis, or the shape of the flutes, in the case of solid taps, may affect the action of the tap decidedly. It is essential to have flutes that are large enough to provide room for the chips, but not so large as to weaken the tap excessively. The flutes should also be so formed and located relative to the axis of the tap that the front cutting faces will have whatever rake may be needed to secure good cutting action. To obtain ideal results, taps should be fluted so that the angle of rake will be in accordance with the material to be tapped; while this can be done to some extent, a great many taps are intended for general work and must be made to suit average conditions as far as possible. In general, taps used principally or exclusively on steel should have positive rake, the plane of the cutting face being a little back of the tap center. The rake angle or the inclination of the teeth, with a radial line, usually varies from about 8 to 12 degrees. Solid taps are given this rake by using a cutter that is either convex, so as to undercut or form a hook-shaped flute or cutting face, or a cutter having straight angular sides and a rounded point may be used, the amount of rake being controlled by the adjustment of the cutter relative to the axis of the tap blank. Various modifications of these two general types of tap fluting cutters are in use.

Plain convex flutes are shown at *A*, Fig. 8. The front and rear faces of the tap lands are similar. If the tap has to be backed out of the hole, the rear edges prevent chips from wedging between the teeth of the tap, which is an advantage, but since the rear sides of the lands are the same as the front, there is likely to be some cutting or scraping action as the tap revolves backward when removing it from the hole. The amount of rake that can be obtained with a convex cutter is also limited, and by under-cutting the rear sides of the lands the tap is weakened.

The form of flute illustrated at *B*, Fig. 8, gives a tap greater strength than one fluted with a plain convex cutter. The front faces of the lands are under-cut to obtain positive rake, the same as though a convex cutter were used, but the rear sides are straight instead of following the curved arc shown dotted. This feature strengthens the tap, and the rear sides are also steep enough to prevent chips from wedging in between the teeth and thread. Of course, there is likely to be more or less wedging of chips between the flutes and the tapped thread with any non-collapsing tap when rotation is reversed for backing the tap out of the hole. The width w of the land of this kind of tap should equal one half the width of the space or one twelfth the tap circumference in the case of a four-fluted tap.

The form of flute shown at *C*, Fig. 8, has been used extensively with some modifications as to the radius of the bottom of the flute and the angle of rake in front of the lands. This flute is milled with a double-angle cutter and the tap may easily be given any amount of positive rake within practicable limits. If the rear sides of the lands have a gradual slope, as shown in the illustration, difficulty is often caused by the wedging action of the chips, which may either mar the thread or result in breaking the tap. The flutes illustrated represent the shape obtained with a cutter having an angle of 30 degrees on one side of the center line and 55 degrees on the other. Some angular fluting cutters have an included angle of 90 degrees, with each cutting edge 45 degrees from the center line.

The amount of positive rake that a tap should have to work satisfactorily in steel should preferably be such that slightly curling chips will be produced. These chips should break up into short lengths and not be so long as to jam tightly in the flute, which might occur if the tap had too much rake. On the contrary, insufficient rake prevents a free cutting action and the metal is pushed ahead of the teeth and compressed until in some cases the tap breaks. Taps that are hook-fluted, or provided with positive rake, cannot be used to advantage for tapping cast brass and cast iron, and either a radial cutting face or negative rake is preferable. Taps that are intended exclusively for brass generally have cutting edges that are ahead of the center as illustrated at *D*, Fig. 8. The plane of the cutting face is usually ahead of a radial line a distance x varying from 1/16 to 1/10 of the tap diameter, which gives negative rake. The tap illustrated at *E* has been extensively used for tapping copper. This is such tenacious material that ordinary taps do not cut it satisfactorily. The tap shown at *E* has but one flute, so as to leave as much bearing surface as possible and prevent the tap from tearing the thread. Another form of tap intended for copper is illustrated at *F*. In this case the flutes are so shaped that the tap has considerable positive rake. If a commercial tap is used on copper, the form of flutes illustrated at *B* is preferable to the plain convex shape shown at *A*, because a tap for any tenacious material such as copper should not have lands that are undercut on the rear side.

Chamfer on End of Tap—Cause of Reaming Action

The length of the chamfer on the leading end of the tap may depend almost entirely on the class of work for which the tap is intended. If threads are to extend close to a shoulder or the bottom of a blind hole the chamfer may be confined to the first annular row of teeth or even be omitted en-

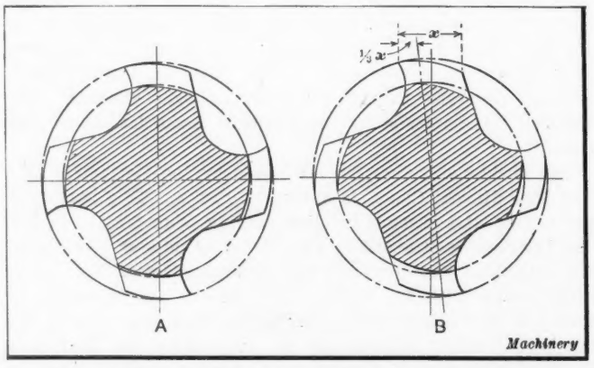

Fig. 10. (A) Tap relieved both on Top and in Angle of Thread. (B) Type of Relief known as "Con-eccentric"

tirely, especially when tapping cast brass or some other material that is easily cut. When the tap can pass clear through the hole or a full thread close to the bottom of the hole is not necessary, it is preferable to chamfer several of the end teeth, the number of teeth often varying from four or five to ten or twelve. If the chamfer is too gradual or extends over too many teeth, the tap may not screw itself into the hole, but may act somewhat like a reamer and merely enlarge the hole as the teeth revolve without advancing along a helical path as when cutting properly. This is due to the fact that each tooth cuts such a shallow groove that it does not offer sufficient bearing surface to force the following teeth to advance; consequently they simply rotate in one position and cut away the metal like a reamer instead of forming a helical thread groove. It is important, however, to chamfer taps for through holes back as far as practicable, because less power is required to drive such taps, and therefore they are subjected to less torsional strain and are less likely to break. Repeated tests made by the Greenfield Tap & Die Corporation show that approximately 25 per cent more power is required to drive a tap having a chamfer extending back over only four threads than one having a chamfer extending over six threads. The four-thread chamfer in the case of a four-fluted tap divides the work between sixteen teeth, whereas the six-thread chamfer divides it between twenty-four cutting teeth. The tap having the longer chamfer also has the advantage of producing a much smoother thread and cuts more closely to size.

The reaming action previously referred to and the failure of the tap to start or catch the thread is usually caused by the use of a tap drill that is too small rather than by an excessive amount of chamfer. In some cases, holes to be tapped are actually smaller in diameter than the root diameter of the thread, so that the end of the tap must ream out the hole. This additional work imposed on the tap prevents it from advancing along a helical path, because the increased resistance to this forward movement is so great that the teeth will not follow along the thread groove as they naturally tend to do, but simply revolve and cut away the metal like a reamer. Even if the tap should begin to advance after being forced partly through the nut, the thread formed in the remainder of the hole would be thin and weak.

An unusual form of tap is shown in Fig. 9. The chamfered edges are ground at an angle F to the axis so that they will cut with a shearing action. The object of this inclined cutting edge is to cause the chips to curl out ahead of the tap instead of collecting in and clogging the flutes, and for that reason the manufacturer (Greenfield Tap & Die Corporation) refers to it as a "gun tap," the name signifying that the tool shoots its chips straight ahead in long curls. Because of this cutting action, two or three flutes which are comparatively shallow may be used, thus increasing the strength of the tap. All the cutting is done on the first few teeth and the rest of the teeth act as a lead-screw for guiding the tap. The grinding is done on the angular cutting edge instead of in the flutes. This tap is especially adapted for difficult conditions or the tapping of tough material.

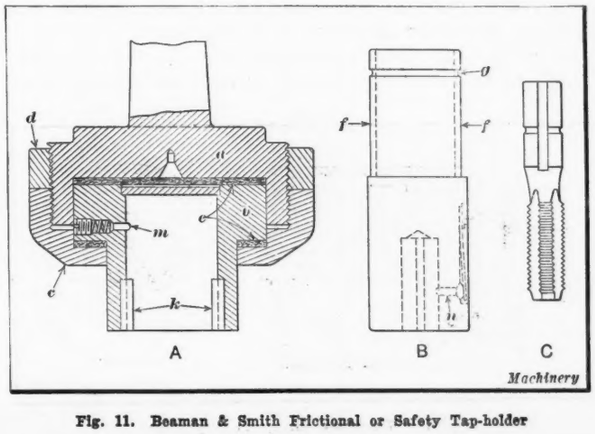

Fig. 11. Beaman & Smith Frictional or Safety Tap-holder

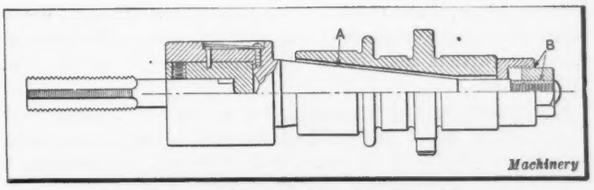

Fig. 12. "Wizard" Friction-drive Tap-holder

Clearance or Relief for Tap Cutting Edges

There are several ways of providing clearance for tap cutting edges so that they will cut freely. We shall consider first taps intended for straight threaded holes. The teeth of such taps may be backed off or relieved like the teeth of a form milling cutter, as shown at A, Fig. 10. In this case, the teeth are relieved on the top and angular sides and also at the root. A tap relieved in this way will cut freely, but it has been objected to on the ground that there is not sufficient support while cutting to produce round, smooth holes; moreover, there will be a reduction in diameter as soon as the front cutting faces are ground for sharpening the tap. To secure better support than is obtained from the points of the teeth relieved as shown at A, taps for threads having flat tops, like the U. S. standard, have been made with teeth that are concentric on the outside but relieved on the angular sides. While such taps cut freely and are well supported by the concentric teeth, both the pitch diameter and the width of flat are reduced by repeated grinding.

The disadvantages of relieving straight taps as previously described led to the introduction of a tool that was given clearance not by relieving the teeth from front to back, but by making the tap a little larger in diameter on the leading end (say, 0.001 to 0.002 inch) than at the shank end. The effect of this slight back taper is to make the tool cut more freely, and a great many taps have been given clearance in this way. Taps without eccentric relief (except on the chamfered end) are preferable for use on automatic screw machines of the type which reverse for backing out the tool, because chips are less likely to wedge between the teeth and mar the thread or break the tap.

Another method, which is regarded by some as the best form of relief, is illustrated at B, Fig. 10. This is known as the "con-eccentric" relief because the teeth are concentric for a distance equal to one third the width of the land, and the rest of the tooth is eccentrically relieved. The object of this form of relief is to provide enough clearance to make the tap cut freely, and at the same time give adequate supporting surface. The tap teeth can also be ground back for sharpening without changing the shape of the cutting edge or the tap diameter. The top of the thread is relieved across the entire width of the land on the chamfered part of the tap to secure a keen cutting edge. The chamfered end is also given greater relief than the straight part to improve the cutting qualities. The angular sides of the teeth on the chamfered part have the regular relief.

Taps for cutting threads in tapered holes must have teeth relieved across the entire width of the land, both on the top and angular sides. If a tapered tap were not relieved in this way, the rear ends or "heels" of the teeth would be higher up on the taper than the cutting edges owing to the inclination of the teeth relative to the tap axis. In other words, the rear end of any tooth would coincide with a larger circular section of the tap than the cutting edge; consequently the cutting edge would not form a space large enough for the rear end of the tooth.

Diameter of Hole before Tapping

The diameters of holes to be tapped may seriously affect the tapping speed, the power required for tapping, the loss of taps as the result of breakage, and the quality of the work. The hole should be somewhat larger than the root diameter of the thread, the amount depending to a certain extent upon the class of work and the kind of material. For ordinary manufacturing, 75 to 80 per cent of the standard thread depth is sufficient, and for some classes of work not more than 50 per cent of the thread depth is required. Tests have demonstrated

that a U. S. standard thread cut to one half the standard depth in an ordinary cold-punched nut will not strip. The tops of the bolt threads also resist the stress, and it is the bolt that breaks.

Tests made by the Greenfield Tap & Die Corporation have demonstrated that a full depth of thread in a nut is practically no stronger than a 75 per cent depth of thread; furthermore, a thread depth equivalent to 75 per cent of the standard is only 20 per cent stronger than a thread of 50 per cent depth. As the thread depth increases beyond 75 per cent, the power required to drive the tap rapidly increases as the full depth of thread is approached. Soft tough material, such as Norway iron, drawn aluminum, copper, etc., should be drilled larger for tapping than hard crystalline materials, such as cast metals. If the holes in the soft tough materials are too small, the tops of the threads will be torn off when tapping, thus decreasing the effective thread depth. When a larger tap drill is used, the tapping action tends to draw the metal toward the top of the thread and increase the effective depth, especially after the tap has been slightly dulled.

If, for any reason, a full depth of thread is required, serial taps should be used. Taps of this kind progressively increase in diameter from the first to the last tap in a set in order to distribute the work more evenly between them. In general, tap drills giving a 75 per cent depth of thread are recommended. As commercial drill sizes will not always be just right, the next larger commercial size will give satisfactory results. The proper selection of tap drills is very important, and if properly attended to, may result in a great reduction in the number broken. The diameter of tap drills for U. S. standard or V-threads may be determined by the following formula, which is intended for a 75 per cent thread depth:

$$\text{Tap drill diameter} = T - 0.75 \times 2D$$

in which T = external diameter of tap or thread;

D = depth of thread.

The depth of a U. S. standard thread = 0.6495 × pitch of thread, and the depth of a sharp V-thread = 0.866 × pitch.

Tapping Square Threads

While the Acme screw thread has replaced the square thread to a large extent because it is stronger and more easily cut, square threads are still of sufficient importance to merit some attention; moreover, those who are responsible for producing good square threads are not always in a position to substitute the superior Acme form. A satisfactory method of cutting square threads by means of taps is to form the threads by a progressive cutting action. This method, which may not be necessary for very fine pitches or comparatively rough threads, involves the use of a set of taps varying in size so as to distribute the work properly. For the finer pitches there may be two taps in a set or as many as four or five if the pitch is relatively coarse. Each tap should have a pilot or extension beyond the chamfered end, as this steadies it and improves its cutting qualities. The pilot of the first tap of the series is simply a smooth cylindrical end from 0.003 to 0.005 inch smaller than the hole to be tapped. The pilots of the following taps have teeth and should be of the same diameter as the body of the preceding tap. It is also advisable to have the teeth in the different taps of a set increase progressively in width. For instance, the teeth of the first tap of a set may have a width of, say, 0.247 inch; the teeth of the second, a width of 0.250 inch; and the width of the finishing tap, 0.253 inch. If the outside diameter of the finishing tap is 1.5 inch, the two preceding taps might have diameters of, say, 1.420 and 1.250 inch, respectively. When such taps are used, the thread groove is gradually made deeper or larger in diameter and wider, so that the final tap of a set serves to take a finishing cut over the entire surface of the thread groove, which is given a smooth finish. If the taps of a set increase in diameter but do not have teeth which progressively increase in width, the sides of the thread groove will not be finished as smoothly. The flutes of square thread taps should be at right angles to the cutting teeth in order to improve the cutting qualities, particularly if the taps are for coarse pitches and must cut away considerable metal. The teeth on the chamfered part of all the taps in a set should be relieved or backed off on top. If square-threaded taps are to be used for machine tapping, the teeth of the chamfered part should be relieved on the sides as well as on top.

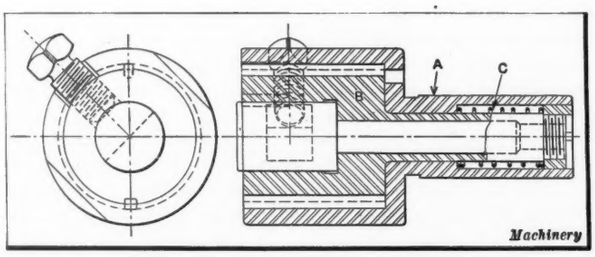

Fig. 13. Tap-holder of Draw-out Non-releasing Type

Lead and Diameter Errors in Tapped Holes

In order to secure accurate fits between screws and tapped holes, it is, of course, necessary to guard against inaccuracy both when tapping the hole and when cutting the external screw thread that is to enter the hole. While this is quite obvious, the relationship between external and internal screw threads is often disregarded, although the direct cause of many thread troubles. When fitting plain cylindrical parts in holes, the manufacturing problem is relatively simple, since the quality of fit usually depends simply upon diameter and finish, but in the case of screw threads, the accuracy and quality of the fit may be decidedly affected either by the lead of the thread or by its shape, in either the screw or the nut, as well as by the respective diameters of the screw and nut. Another feature of the screw thread is that errors are not always apparent at first, as, for example, when a screw seems to fit tightly but has a poor bearing in a nut or tapped hole because of a lead error.

The errors in screw threads produced either by tapping, by means of dies or by some other method, may be due to inaccuracy in the tool or the conditions under which the tool is used. Whatever the method or conditions, it is, of course, impossible to eliminate all error, and especially where the error—as in the case of screw threads—may be in the lead of the thread, the pitch diameter, the sectional shape of the thread, or the difference between the curvature of the thread and a true helix. In order to allow for these errors, which may be very small if considered singly but serious when combined, it is essential to adopt limits or tolerances between the threaded parts. This question of limits is difficult to deal with, particularly in a general discussion of the subject, since a suitable limit for one grade of work might be entirely too large or small for other threaded parts requiring greater or less accuracy. In general, maximum and minimum pitch diameters should be adopted for both taps and screws. The maximum pitch diameters of the screw threads should be slightly less than the minimum pitch diameters of the taps to allow the largest screw to enter the smallest hole, although if the two sizes were exactly the same, there might be no difficulty in assembling, because taps, as a rule, cut a certain amount over size, the amount varying according to the conditions to be referred to later. Tables of limits recommended for interchangeable screw threads and tapped holes were published in MACHINERY, February, 1917, page 480.

In buying taps some manufacturers specify very small limits when the required degree of accuracy in threaded parts

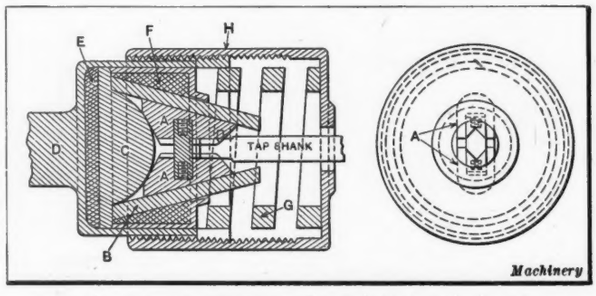

Fig. 14. Woodstock Safety Tapping Chuck

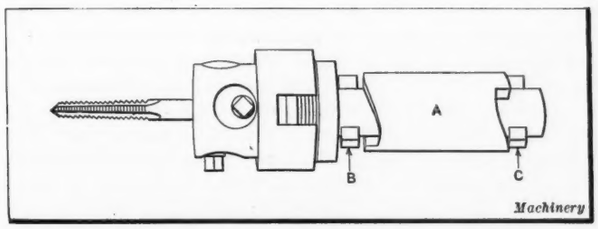

Fig. 15. Errington Friction Tap-holder of Releasing Type

could be obtained with ordinary commercial taps if sufficient care were taken in their use and in making the screws which are to enter the tapped holes. While an accurate fit between threaded parts depends upon both the tap and screw, some users of taps forget that the screw may be at fault. This point is illustrated by the experiences of all tap manufacturers. Taps made for customers who specify very close limits of accuracy are frequently condemned as inaccurate, when the screws inserted in the tapped holes are the cause of the trouble, due, in many cases, to an error in lead. It is evident that little is to be gained by using high-priced taps that are made unusually accurate by employing special methods, if little or no attention is given to the limits of error in the screw; in fact, so far as pitch diameter is concerned, it is usually easier to control the diameters of the screws than the diameters of tapped holes, although with the adjustable taps now available extremely accurate work may be obtained, and holes in duplicate parts may be held to a standard size within small limits.

Many taps, particularly when used in a machine, tend to cut over size. This slight enlargement of the hole may be the fault of the tap or it may be caused by the method of holding it; the size of the hole before tapping is also frequently the cause of inaccurate work. If the threaded part of a solid tap is warped or bent slightly by the hardening operation, this will cause it to cut large, the error increasing as the length or depth of the tapped hole increases, up to the full length of the tap body. When taps are made of steel that is not properly rolled or annealed they may shrink unevenly in hardening or lose their circular form. If the teeth of an evenly fluted tap do not lie in a circular path, the tap will chatter and cut over size. A tapped hole that is too large may also be caused by the crowding of the metal resulting from passing a tap through a hole that is too small. Errors may also be due to excessive clearance or rake on the chamfered part of the tap, uneven chamfering on the different lands, excessive under-cutting in the tap flutes, or too much relief in the thread angle. Lack of alignment between the tap and work is frequently the cause of tapping holes that are too large and tapering. The extent to which errors from lack of alignment may be reduced, if they are not eliminated entirely, by the use of floating tap-holders depends upon the design of the tap-holder and the amount of alignment error. By studying the different causes of error mentioned, tapping troubles that are the direct result of one or a combination of these causes may be greatly reduced or eliminated, and holes may be tapped accurately enough for ordinary commercial requirements without purchasing taps made to order and within specified limits of accuracy which require unusual and unnecessary refinement in their manufacture.

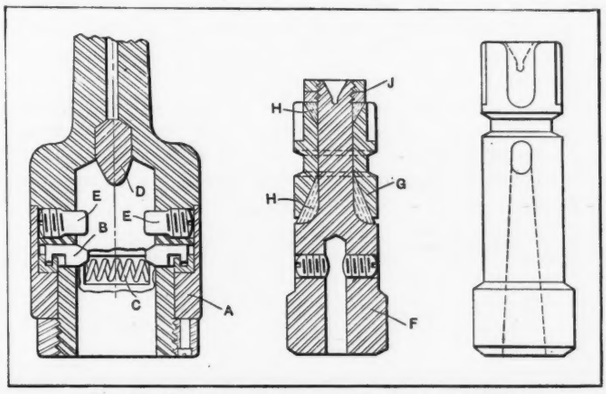

Fig. 16. Horton Quick-change Collet Chuck and Collets

Holding and Driving Taps

The method of holding and driving a tap may vary according to the type of machine used for tapping, the kind of tap, or the class of work. The holder may be designed to hold the tap rigidly or to allow it to slip or stop in case the resistance to tapping becomes excessive. Tap-holders may also be arranged to provide a certain amount of lost motion or floating movement either in a longitudinal or a lateral direction. The object of the longitudinal movement is to allow the tap to advance according to its own lead and independently of the advance movement of the driving spindle or slide to which it may be attached. The lateral floating movement is to compensate for any lack of alignment between the hole being tapped and the tap-driving spindle or holder, although some taps as well as dies that are supposed to have this self-adjusting feature do not line up properly with a hole that is out of line because of the frictional resistance of the driving pins or lugs, which prevents a free floating movement. Tap-holders for solid or non-collapsing taps may be of the releasing or non-releasing type, as described later. Another type of tap-holder is designed especially to permit inserting or removing taps easily and quickly. There are also tap-holding chucks or tapping attachments that are equipped with a mechanism for reversing the rotation of a non-collapsing tap to back it out of a hole. Many tap-holders are designed along the same general lines as die-holders.

Frictional Tapping Chucks

In order to prevent breaking power-driven taps when an unusual resistance is encountered, they are sometimes held in frictional chucks arranged to allow the tool to slip before it is strained to the breaking point. The need for a frictional drive may arise when the tap strikes the bottom of a blind hole, or if the hole before tapping is not large enough, the tap may be subjected to excessive strains. A design of frictional holder that is intended for driving both drills and taps is shown at *A* in Fig. 11. This holder (which is made by the Beaman & Smith Co., Providence, R. I.) has a shank *a*, a friction socket *b* which receives the tap-holder, a cap nut *c*, and a lock-nut *d*. Fiber washers *e* are placed on each side of the friction socket flange and nut *c* is tightened until there is just enough friction between parts *a* and *b* to drive the tap under normal conditions. If the tap should encounter unusual resistance or strike the bottom of a blind hole, it will slip instead of breaking, provided nut *c* is not set up too tight.

With the frictional tapping collet illustrated in Fig. 12, the frictional resistance is obtained by means of a tapered plug *A*, which is drawn into a fiber lined hole of corresponding taper by a differential screw *B*. As the illustration shows, the nut for making the adjustment is threaded internally and externally. These threads vary in pitch so that a sensitive and powerful adjustment is obtained. This frictional collet (which is the product of the McCrosky Reamer Co., Meadville, Pa.) is used in the quick-change collet chuck illustrated in Fig. 17 and described later. By supplying collets for the different taps that may be required in succession on the same job, each size tap may have its own friction properly adjusted, in order to avoid readjusting the friction for different sizes.

The Woodstock safety tapping chuck (made by Peter Bros. Mfg. Co., Algonquin, Ill.) is arranged to hold the tap by the square end of the shank only, between the jaws *A* (see Fig. 14). These jaws are located in a slot in the friction cone *B*, which prevents them from turning except with the cone. A circular projection on part *C* fits into the slot of cone *B* and forces the jaws downward for gripping the square end of the tap shank when the outer shell of the chuck is screwed up or tightened. The tap is prevented from pulling out by a small pin in one of the jaws, which engages a catch or notch formed on the square end of the tap. Between part *C*, which is called the "rocker," and the stem or shank *D*, there is a fiber friction disk *E*. This fiber disk forms part of the frictional surface through which the tap is driven. In addition, there is

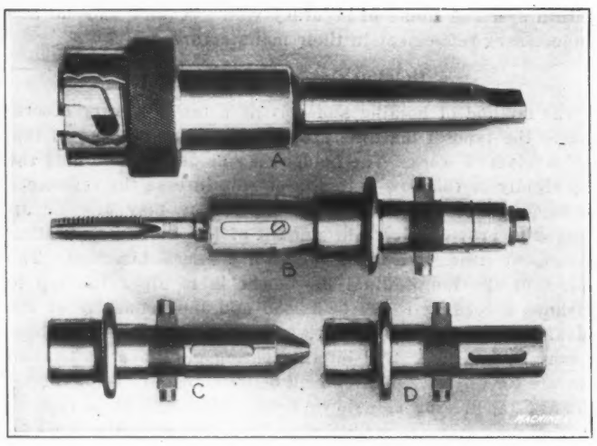

Fig. 17. "Wizard" Quick-change Chuck and Collets

a conical friction surface at *F* formed of fiber contained within a steel case surrounding the cone *B*. This conical cup is prevented from turning with cone *B* when the latter slips, by two pins that engage slots in the inner shell of the chuck body. The cup *F* is held in contact with cone *B* by spring *G*, the tension of which is regulated by screwing the outer shell *H* in one direction or the other. Graduation lines on the body of the chuck serve as a guide in securing the proper amount of frictional resistance. The graduations are for ordinary tapping operations in steel. When tapping exceptionally tough material like nickel steel, it might be necessary to screw the shell, say, half a revolution beyond the graduating line, whereas for tapping cast iron, the shell might not be advanced to the graduating line within half a revolution.

Tap-holders of Releasing and Non-releasing Types

Tap-holders for non-collapsing taps are made in the releasing or non-releasing type the same as die-holders. The non-releasing holder should preferably have enough lengthwise floating movement to allow the tap to follow its own lead,

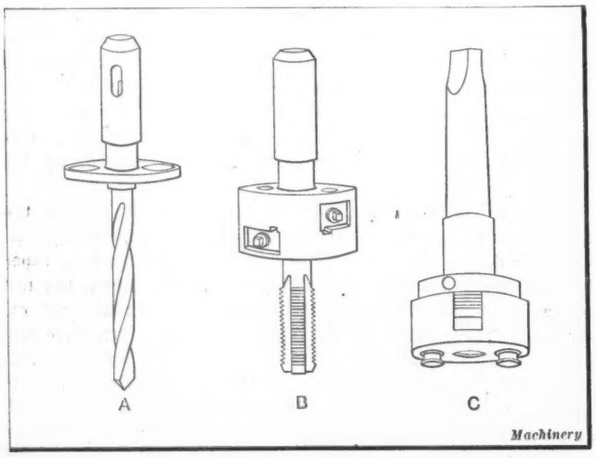

Fig. 18. Errington Drill-holder, Tap-holder, and Quick-change Chuck of Frictional Pin-drive Type

but the tap is at all times prevented from revolving. A simple design of non-releasing holder which is used on many Brown & Sharpe automatic screw machines is shown in Fig. 13. This consists of two main parts *A* and *B*. The outer part *A* is held in the turret, whereas the tap is held in the inner part *B*. The latter is free to move a limited amount in a lengthwise direction against the tension of spring *C*.

With the releasing type of holder the tap is prevented from rotating until the tapping operation is completed, when it is released. One of the Errington releasing holders is illustrated in Fig. 15. The shank of the holder passes through a sleeve *A*, having clutch teeth formed on each end. When the tap is entering a hole, the clutch pins at *B* are in engagement with the sleeve and the tap is prevented from rotating. When the forward movement of the turret-slide is arrested by stops previously set, the tap continues to advance until the pins at *B* are disengaged from the clutch sleeve, and then the tap revolves idly with the work. As soon as the work-spindle is reversed and the turret with sleeve *A* is moved in the opposite direction, the clutch pins *C* come into engagement with the sleeve and hold the tap stationary while it is being backed out of the tapped hole. This particular holder is provided with a friction drive, which is adjusted to slip and prevent breaking the tap in case the latter is subjected to excessive stresses or comes against the bottom of a hole. There are various other designs of tap-holders in both non-releasing and releasing types, many of which are similar to die-holders.

In many shops it is the practice to use non-releasing holders on automatic screw machines, and the releasing type on turret lathes or screw machines which may be reversed by hand, especially if a thread is to be cut close to a shoulder. The reason for using a releasing holder on a machine that is reversed by hand is to prevent breaking the tap by allowing it to revolve with the work after being fed in to a predetermined depth. If the holder were non-releasing and the machine were not reversing at exactly the right time, the tap might be broken or the thread damaged.

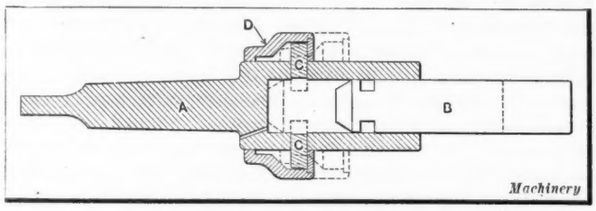

Fig. 19. Sectional View of Quick-action Chuck with Operating Collar in Position for releasing or inserting Collet

Tap-holders Designed for Rapid Insertion or Removal of Taps

When tapping operations are performed on drilling machines in connection with drilling operations, chucks are often used that are arranged for holding either drills, taps or other tools interchangeably, and these chucks or holders are so designed that a drill may be replaced by a tap, or *vice versa*, very quickly. Whether it is advisable to drill all holes to be tapped and then rehandle the work for tapping may depend upon the size of the casting or forging and the relation between the tapping and other operations. When tapping duplicate pieces on a drilling machine that are too heavy to adjust or center themselves with the tap, or when the work is clamped in position, it is common practice to drill, tap, and possibly insert a stud in the tapped hole, in one series of operations, instead of rehandling the parts for tapping. It is for operations of this kind that the quick-change chucks, collets, or holders for drills, taps, etc., are of especial value.

The holder or socket illustrated at *B*, Fig. 11, is used in connection with the Beaman & Smith friction chuck shown at *A*. This holder is splined at *f* on each side, and these splines engage keys *k*. The small spring-pin *m* engages groove *g* on the holder and prevents the latter from falling out of the chuck when there is no upward pressure. The tap *C* is also driven by side keys and is prevented from dropping out by the spring pin *n*. The drill sockets, which are also inserted in this friction chuck, have a standard taper hole for receiving drill shanks.

The quick-change collet chuck illustrated in Fig. 16 is so arranged that either the tap collet or drill collet can be inserted by simply grasping the knurled sleeve of the chuck and holding it back against the rotation of the spindle as the collet is pushed into place. When the sleeve *A* is held against

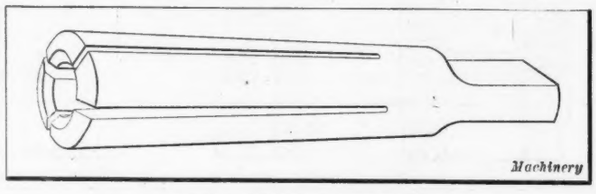

Fig. 20. Scully-Jones Tap Chuck

rotation, the retaining dogs *B* are withdrawn by the action of cam surfaces. As the collet is pushed up into the chuck it is centered by the tool-steel plug *D*, which engages a conical shaped center formed in the end of the collet. The studs *E* come into contact with flat surfaces near the end of the collet and provide a positive drive. As soon as sleeve *A* is released, the retaining dogs *B* are forced inward by the action of spring *C* and engage an annular groove extending around the collet. These dogs or pins *B* prevent the collet from dropping out of the chuck. Both tapping and drill collets are shown in the illustration. The tapping collet is provided with an adjustable friction for safeguarding the tap against breakage. The conical frictions *H*, which are of fiber, are located between the body *F* of the collet and the sleeve *G*. The tension of the friction is adjusted by the nut *J*, so that the tap will slip if the torsional strain becomes excessive. The collet is made 0.015 inch smaller than the bore of the chuck to provide a slight floating movement. This chuck is manufactured by E. Horton & Son Co., Windsor Locks, Conn.

Another chuck designed for rapid insertion or removal of tools is shown at *A* in Fig. 17. Some of the collets used in conjunction with this chuck (manufactured by the McCrosky Reamer Co.) are also shown in the illustration. These collets each have two driving lugs projecting from the side that engage slots in the chuck when in use. The chuck consists principally of a driving body, which is equipped with a Morse taper shank to fit the drill-press spindle, and a slotted collar for holding the collet up into the driving body. This collar is held in position by a headless screw, and it is provided with a coiled spring which keeps it normally in the closed position. A thin sleeve is screwed over the slotted portion of the collar merely to cover up the slots and screw. A slight resistance to the motion of the collar, such as would be caused by grasping it with one hand while the spindle is in motion, opens the slot in the chuck so that a collet may either be inserted or allowed to fall out of the chuck. The spring previously referred to then throws the collar back to the closed position, which serves to lock the collet into place. A friction drive tapping collet for use with this chuck is shown at *B*. The particular collet illustrated is intended for the Beaman & Smith style of tap shank. The collet illustrated at *C* is provided with a Morse taper hole and is intended for holding a tap drill or other tool having a tapered shank. The collet is one solid piece of steel, and it will be noted that the upper end has a conical point. The upper end of the slot in the chuck *A* is angular, and this tends to force the collet upward so that it is accurately centered by the conical end which engages a seat in the chuck. This collet is so made that it bears in the chuck only on the taper end and on that part of the collet between the driving lugs and flange. This flange or collar is convenient when pushing a collet up into the chuck or when catching it when released. The collet shown at *C* is held rigidly in the chuck, whereas the form illustrated at *D* has a floating movement.

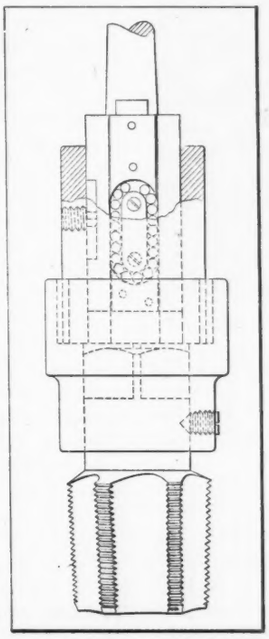

Fig. 21. Cincinnati-Bickford Friction-reducing Tap Chuck

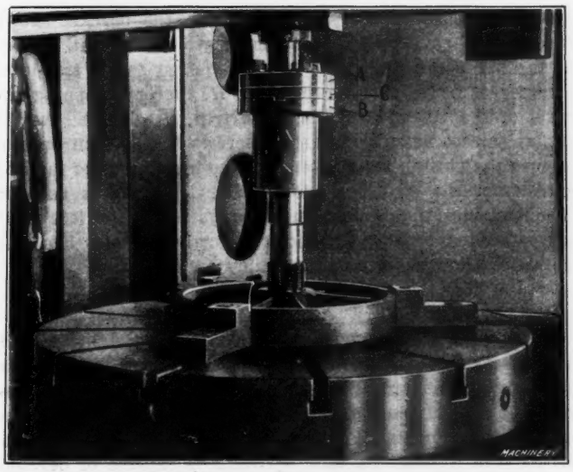

Fig. 22. Tap-holder designed on Principle of Oldham Coupling

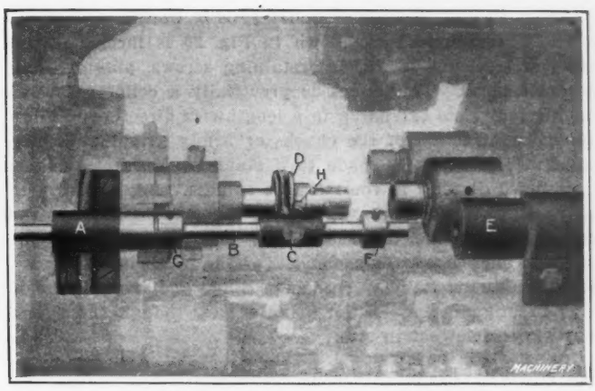

Fig. 23. Tap Resetting Attachment on Acme Multiple-spindle Automatic

The type of quick-change tool-holders illustrated at *A* and *B*, Fig. 18 (product of the Errington Mechanical Laboratory, 39 Cortlandt St., New York City), is intended for use with a friction "slip-chuck" *C*, or an automatic reverse chuck in case the drilling machine is not equipped with a tapping attachment. The two driving pins seen on the lower face of the chuck have retaining collars or flanges at the end and engage holes in the flange of drill-holder *A*, or holes in the body of the tap-holder *B* when either the drill- or tap-holder is in use. A tool-holder can be inserted in the chuck by simply pushing it up into place, or it can be removed from the chuck while the spindle is revolving by depressing a releasing spring. The automatic-reverse chuck referred to is arranged to reverse the motion for backing out the tap. This chuck is arranged to receive the quick-change tool-holders, and may be locked for drilling by pulling out a slide. When tapping, this slide is pushed in, which enables the motion of the tap to be reversed, the same as when using the regular automatic-reverse tapping chuck. The chuck with the pin drive is adapted especially for the heavier classes of tools. For comparatively light weight tools that can safely be dropped out of the socket, a ball-drive chuck is recommended. The shank of this chuck is bored out to receive the tool-holding socket, which has concave crosswise grooves near the upper end which are engaged by the two driving balls. When a sliding sleeve is raised the balls fly outward, thus releasing the tool socket. As soon as another socket is inserted in the chuck, the sleeve is lowered and an inner beveled surface on it forces the balls in to the driving position. Tools may be inserted or removed while the spindle is in motion.

The quick-action chuck shown in section in Fig. 19 is operated by raising or lowering a sliding collar, for inserting or removing a tool-holding collet. The taper shank *A* enters the machine spindle, the collet *B* holds the tap or other tool, the two keys or "pawls" *C* drive the collet by engaging the slots shown, and the sliding collar *D* either holds the pawls *C* in the driving position or allows them to move outward in a radial direction for releasing the collet. The sectional view shows the driving pawls in the outward position to permit inserting or releasing a collet. When the sliding collar is pushed downward, the pawls come into contact with a conical surface and are forced inward to the driving position, as indicated by the dotted lines. This chuck is manufactured by the Quick-Action Chuck Co., Grand Rapids, Mich. The collet with its tap, drill or other tool may be inserted or removed from the chuck while the machine spindle continues to revolve.

Socket or Collet-Type of Chuck

The tap-driving chuck shown in Fig. 20 is formed of one piece of steel and is without retaining screws, pins or other separate parts. This chuck is practically a collet or socket having four slots extending in a lengthwise direction to allow enough contraction of the chuck for firmly gripping the tap shank. The chuck is made to a standard Morse taper and is inserted directly in the machine spindle. Any pressure in an axial direction naturally causes the flexible body of the chuck to grip the tap shank, the grip increasing as the pressure increases. This chuck (which is made by Scully-Jones & Co., 647 Railway Exchange Bldg., Chicago, Ill.) holds taps in alignment with the spindle even though the shank may vary somewhat in size.

Friction-reducing Tapping Chuck

Poorly tapped holes may be due to the frictional resistance of the tap-driving spindle to motion in a lengthwise direction.

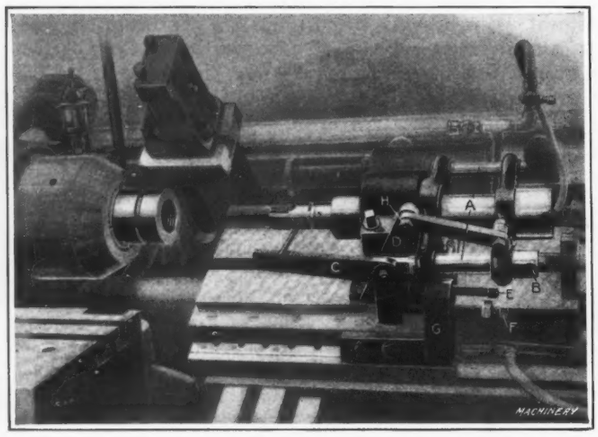

Fig. 24. Tap Resetting Attachment on Gridley Single-spindle Automatic

The feather or key that drives the spindle of a drilling machine is subjected to considerable pressure, particularly when tapping rather large holes, and the natural tendency of the tap to advance or screw itself into the drilled hole is partially or entirely resisted in some cases. The result is that the tap cuts a poor thread or fails to start and simply enlarges the end of the hole like a reamer. The tap chuck shown in Fig. 21 (made by the Cincinnati Bickford Tool Co., Cincinnati, Ohio) is so constructed that the tap can advance independently of the driving spindle, and the frictional resistance is reduced to a minimum by means of ball bearings. The central part of the chuck, which engages the machine spindle, connects with an outer sleeve by means of two rectangular shaped keys which are surrounded by ball bearings, as the illustration shows. The lower end of this sliding sleeve is attached to the tap-holder proper. In tapping a hole, the operator exerts a slight pressure on the tap when it first comes into contact with the work. The tap then advances in accordance with the pitch of the thread, the frictional resistance to this movement being reduced to a minimum by the ball bearing driving keys referred to. This friction-reducing feature tends to prevent reaming action or the stripping of the thread, especially when driving comparatively large taps, which without the ball bearing feature would have to advance against considerable frictional resistance.

Tap-holder Designed on Principle of Oldham Coupling

The tap-holder illustrated in Fig. 22 applied to a vertical boring mill is similar in principle to the well-known Oldham coupling. The particular operation shown is that of tapping lathe faceplates. The holder is formed of three sections *A*, *B* and *C*. Part *A* is attached to the tool-slide of the boring mill, part *B* holds the tap, and the central section *C* has a tongue on the upper face engaging a groove in *A*, and a tongue on the lower face engaging a groove in *B*. These tongues are at right angles, so that the tap-holder is free to move laterally in case the tap is not in alignment with the hole. The three sections of the tap-holder are held together by four large cap-screws that are threaded into the lower half of the coupling but pass through enlarged holes in the central section and the upper part that is attached to the tool-slide. Various classes of tapping attachments and tapping machines will be described in the December number.

Resetting Collapsible Taps

The method of resetting collapsing taps varies according to the construction of the tap and may depend in some cases upon the type of machine used for the tapping operations. Collapsing taps of the non-revolving class, which are intended for use in turrets, etc., commonly have a lever projecting from the side which is used for resetting the tap after it has collapsed, as previously explained. This lever may be operated by hand, or the machine, if an automatic type, may be equipped with some form of projecting part arranged to engage the closing lever as the tap and turret-slide are withdrawn after the tapping operation. Some collapsing taps designed to revolve have a sliding flange or collar which engages a suitable collar or stop and serves to reset the tap.

The special tap resetting attachment for a "Namco" tap applied to an Acme multiple-spindle automatic is shown in Fig. 23. The tap, in this case, is arranged to revolve when cutting a thread. The bracket *A*, carrying shaft *B*, is bolted to the main tool-slide of the machine so that shaft *B* is parallel with the tap-spindle. Yoke *C* engages the spool or grooved collar *D*, which is free to slide on the tap proper. Stop *E* is bolted to the cylinder casing of the machine to terminate the travel of the tap. The amount of travel is controlled by the adjustment of collar *F* on rod *B*. When the tap is cutting, the forward travel of the tool-slide carries stop-collar *F* into contact with stop *E*, which is drilled to receive the projecting end of rod *B* and serves as a guide. When the work has been tapped to the required depth, the forward travel of the tool-spindle is stopped and the chasers collapse as described in connection with the "Namco" tap, illustrated in Fig. 2. As the tool-slide recedes from the work to allow the work-spindles of the machine to index for the next operation, a closing attachment operates in the following manner: The backward travel of shaft *B* is accelerated and yoke *C* engaging spool *D* is stopped by contact with collar *G;* as the tap proper continues to recede with the backward movement of the tool-slide, spool *D* remains stationary, causing the resetting pin *H* to travel down the inclined cam surface shown, thus resetting the tap for the next operation.

The resetting attachment for the "Namco" tap, as applied to the Gridley single-spindle automatic, is shown in Fig. 24, and is similar to the mechanism used for self-opening dies. This attachment is bolted to the slide on the turret and consists of guide-rods *A*, a spring at *B* for starting the tap onto the work, a closing lever *C*, a stop-lever *D*, an adjusting screw *E* for the stop-lever, an adjusting screw *F* for the closing lever, and a stationary stop *G* bolted to the side of the turret. The operation is as follows: When the turret is moved forward by the regular cam equipment of the machine and the tap is about to engage the work, the spring at *B*, controlled by stop-lever *D*, causes the tap to start cutting, the bracket shown traveling on guide-rods *A* for the length of the cut. When the tap has entered the hole to the required depth, stop-lever *D* ceases to hinge at fulcrum point *H*, thereby stopping the travel of the tap and causing it to trip or collapse. As the mechanism recedes, the adjusting screws *E* and *F* in bracket *G* cause the closing lever to engage the handle of the tap and reset it for the next operation. When this tap is used on other machines, the mechanism may require more or less modification. When tapping deep holes, special equipment has been applied to allow the tap to cut to any required depth.

* * *

The propelling machinery of the superdreadnought U. S. S. *Tennessee*, now being constructed, will consist of four motors, each driving one propeller shaft, and developing 6700 horsepower at 175 revolutions per minute. The current for the motors will be furnished by two standard Westinghouse steam turbo-driven alternators, each of which is capable of developing a maximum of 13,500 horsepower.

COMMON AND SPECIAL MICROMETER CALIPERS[1]

ILLUSTRATIONS OF USE IN TOOLMAKING AND MANUFACTURING

BY F. SERVER

"WHAT can it do for you?" is perhaps the most pertinent question that can be asked about a well-known tool that is making big strides in its own field in addition to finding many special applications. This tool is the micrometer. It is a precision measuring instrument, an adjustable gage in which the units of measurement are 0.001 inch or 0.01 millimeter. The micrometer caliper is an important factor in interchangeable manufacture which now means more to the nations at war than ever before. We are supplying the armies in Europe with American products measured in inches that will interchange with products made to metric measurements. While the development of micrometers has been interesting, it is their applications to special conditions that will be discussed in this article.

Typical examples are shown in Fig. 1, which illustrates a group of Slocomb micrometers of different designs. Following this in Fig. 2 is shown a group of tools of various construction, running from the one-inch size to the larger sizes. Referring to Fig. 1, the first illustration shows a tube micrometer, and, as its name implies, this micrometer is used for measuring thicknesses of the walls of tubing, rings or any similar class of work. The illustration at the right of this shows a thread micrometer of familiar construction, which is used for comparing or transferring thread measurements from a standard to the work being machined. As a micrometer of this type does not measure points diametrically opposite, care must be taken in its application. The illustration in the center of Fig. 1 shows a micrometer which is adapted for measuring the thickness of a plate at some distance from the edge, this being made possible by the long gap construction. By having the anvil of this micrometer rounded, it can also be used for measuring tubing. The lower view at the left shows a ½-inch micrometer which is used for measuring paper; this is provided with special anvils of large diameter, thereby providing a large contact surface for the paper or cloth. The illustration in the lower right-hand corner shows a ½-inch micrometer with part of the frame cut away and the anvil rounded over. This is used for measuring the walls of tubing and pieces of various other shapes and projections of a similar kind, where the depth is not too great.

[1] See also "How We Came to Have the Micrometer Caliper," in the June, 1915, number of MACHINERY.

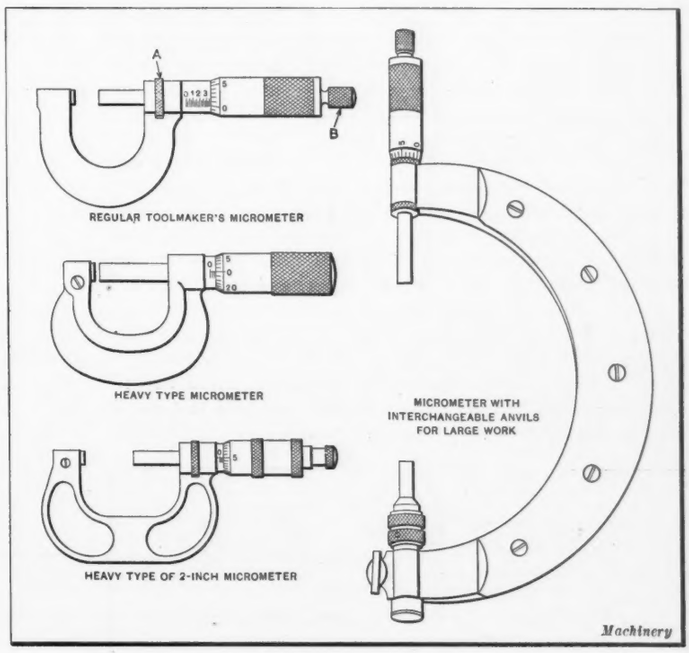

Fig. 2. Group of Standard Micrometers of Different Types and Sizes

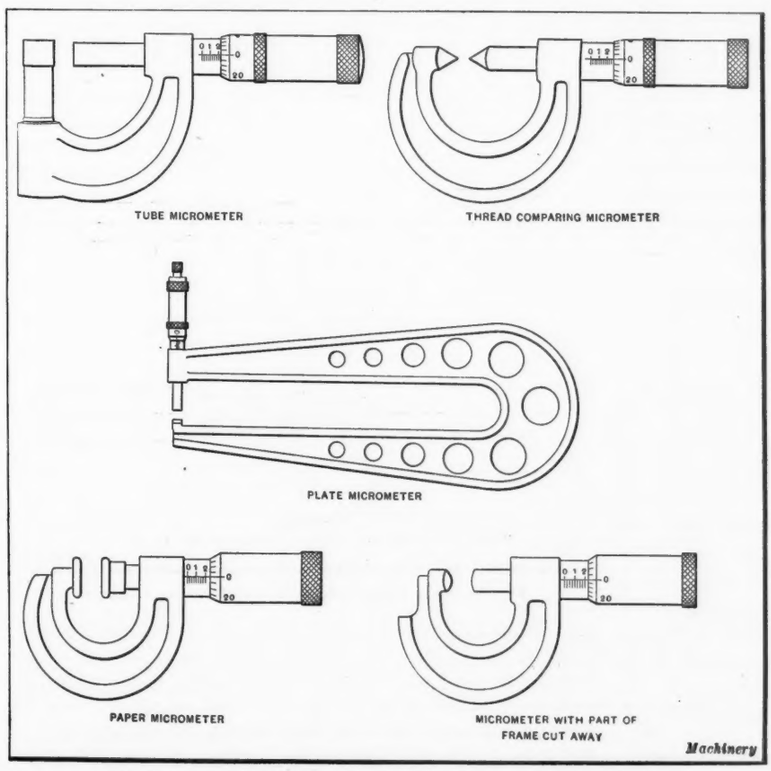

Fig. 1. Group of Special-purpose Micrometer Calipers of Various Designs

The micrometers illustrated in Fig. 2 are a collection of standard tools, the one in the middle at the left being a heavy type micrometer having a drop-forged frame. The one above this is the familiar toolmaker's micrometer, which has a lock-nut *A* and a ratchet stop *B*. Both of these micrometers have a one-inch range. The micrometer shown in the lower left-hand corner measures from one to two inches; and is a heavy-type tool with a lock-nut and a ratchet stop. The micrometer shown in the right-hand view is adapted for measuring large work, and it is provided with a ratchet stop, rubber grips and interchangeable anvils. By means of the latter feature quite a large range of work may be measured. A micrometer caliper that has a number of patented features enabling it to meet special requirements in tool-room use is illustrated in Fig. 4. This micrometer has a flat surface *A* ground at right angles to the spindle, and there is a hole *B* in the anvil. This tool is put on the market with graduations to 0.0005 inch and also with a double row of figures, one set of which reads in the usual manner, and the other from zero at the open end to 1.000 inch with the anvil and spindle together. The rod shown at *C* is used for measuring depths in the same manner as when using a depth gage.

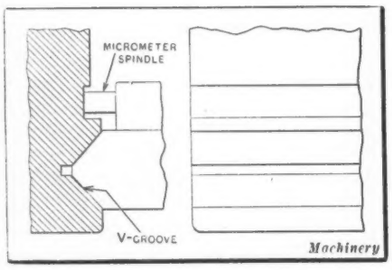

Fig. 3. Use of Micrometer shown at Bottom of Fig. 7

A micrometer of special construction, as applied for measuring a drawn steel part, is shown in Fig. 5. The work is shown in section, and this micrometer measures the thickness from the outside of lug *A* to the inside surface of the wall. This tool is built up with a regular micrometer head *B* and a long anvil *C*, while the frame *D* is forged from machine steel. A micrometer of rather unique construction, but which nevertheless is a practical tool, is shown at the top of Fig. 6. This measures from 0 to 1.000 inch at end *A*, and from 1.000 inch to 2.000 inches at end *B*, thus combining two tools in one. This tool is not as convenient to handle as a micrometer which measures only one range; and, in addition, it costs almost as much to make as two separate micrometers, while two micrometers could be used by two persons and this tool can be used by one only, thereby lessening its value.

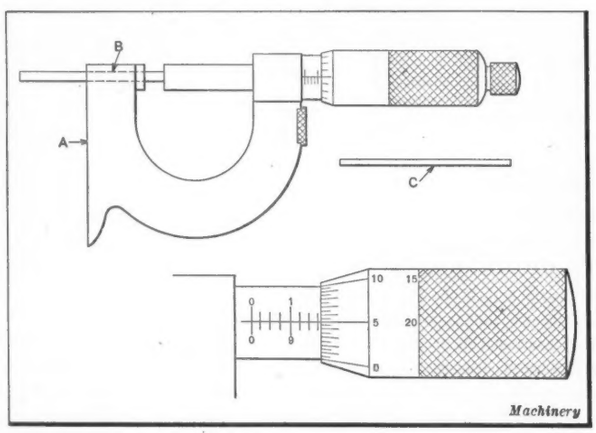

Fig. 4. Micrometer provided with Double Set of Graduations and Depth Plug

In the lower view of Fig. 6 is shown a tool designed on the built-up principle like the Johansson gages. This tool is patented (as are many of the others here shown) and measures from 0 to 6.000 inches, this being accomplished by having a set of end measures or spacers *C*, which are placed against a lug *D* in the spindle frame *E*. These end measures vary in length by inches, and after placing the required lengths between the spindle frame and anvil frame in the tube, other end measures are placed in back of the spindle frame. The whole is then locked by the knurled screw *G* and the micrometer is arranged for measuring a one-inch range in the usual manner, this range being, for example, from 2.000 to 3.000 inches. By rearranging the blocks, any other one-inch range may be had within the capacity of the tool. It will be noticed that on the end of the sliding bar at the knurled end *G* there

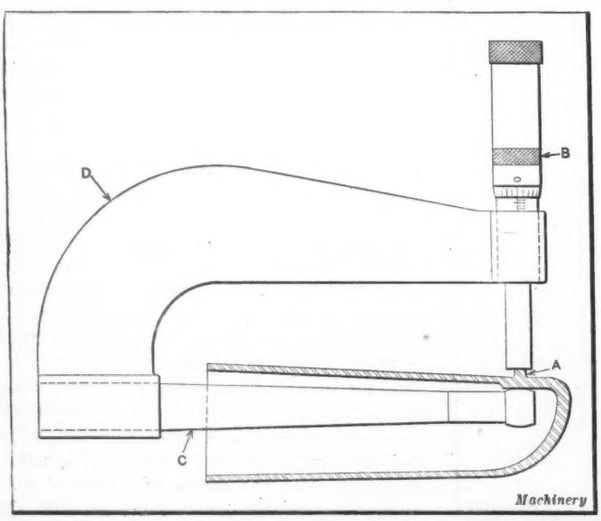

Fig. 5. Micrometer for measuring Height of Lug A from Inside of Shell

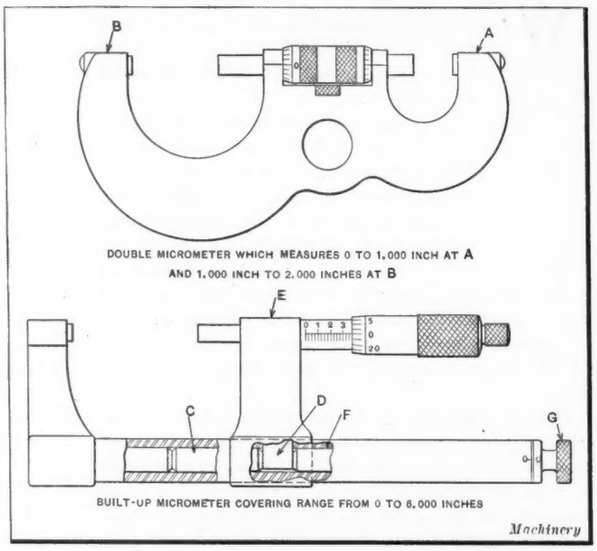

Fig. 6. Two Types of Micrometers covering Large Range of Measurements

are two zeros which must coincide in order to indicate the amount of pressure that has been applied in tightening the nut; this also indicates if there is any dirt between the end measures.

Three examples of measuring with micrometers are illustrated in Fig. 7, and each of the tools shown is well adapted to the class of work that is shown being measured. The upper view shows a two-inch micrometer measuring a three-sided piece across the flats. In this tool the spindle *A* is slightly

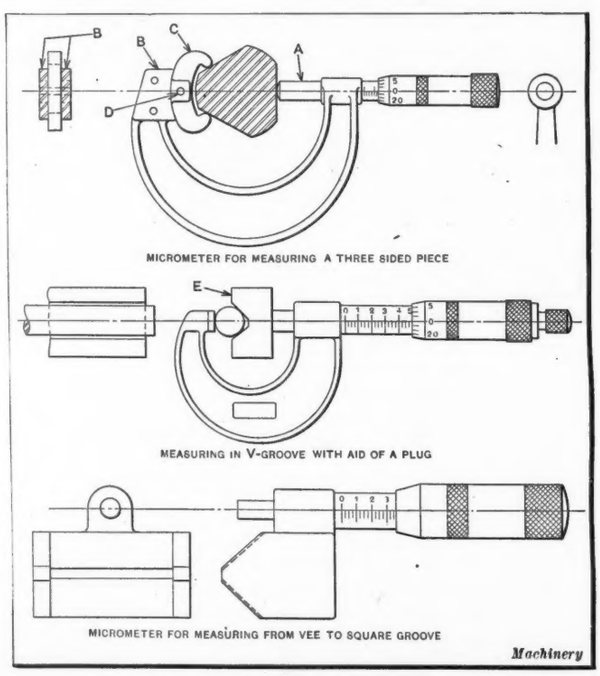

Fig. 7. Three Special Applications of Micrometer Calipers

rounded at the measuring end, while the anvil is of a special construction as follows: Pinned to the sides of the caliper frame are two plates *B*, and between these plates a floating anvil *C* is placed, which is free to swivel on pin *D;* thus the work is measured between three points. In using a tool of this type it is a good plan to test it occasionally with a standard, as the rounded points wear fast. This tool is best adapted

for making comparative measurements.

In the view at the center of Fig. 7 a micrometer used with a standard plug is shown. The measurement being taken is obvious, the object being to machine the V-groove to the correct distance from the bottom of block *E*. In the lower view is shown a tool that must be carefully used, but that, in the hands of a careful man, will give good results. This tool measures from a V-groove to a planed slot at one side of the vee. In using it, the workman holds the formed block portion of the micrometer down snugly into the vee, the weight of the form being so proportioned that it will counteract the weight of the micrometer portion of the tool. This tool takes a relative measurement in the usual manner. Fig. 3 is an enlarged view showing the application of this last tool, this being a cross-sectional view of the spindle and vee portion of the micrometer. Figs. 3 and 7 show some of the advantages of measuring with a micrometer by making simple changes in the tool, and oftentimes the necessity for making expensive gages may be avoided by the application of a special tool in the form of a micrometer caliper.

In referring to the micrometer in this article it is not intended to convey to the reader the idea that this tool is limited to the one- and two-inch sizes found in any toolmaker's kit, as these tools are now made to measure much larger sizes. In Fig. 8 a set of micrometers is shown which measure from 12 to 24 inches; and to the right a large micrometer is shown which has a three-inch range. The latter has interchangeable anvils varying in length by inches, while the head end measures the intermediate range of sizes in the usual manner. In the lower view of Fig. 8, a bench micrometer is shown, having a six-inch range. This tool has large dials so that the reading is very much magnified, and interchangeable dials for coarse or fine measuring may be used. In the illustrations which are to follow a number of different means employed for measuring will be illustrated; these consist of examples taken from practice, and in some cases show the micrometer with slight alterations which are made necessary by various conditions of use.

Referring to Fig. 9, three micrometers are shown measuring different points on a stud. The first tool with a ball point anvil is shown measuring the depth of a recess in the head; this measurement is being taken from the end of the work, and it will be noticed in this connection that the anvil has been rounded suitably to fit into the groove. The micrometer in the center, known as a "reduced point micrometer," is for measuring at the bottom of narrow grooves, and, as will be noted, the points have been turned down until they are small enough in diameter to allow the tool to be readily slipped through the groove. The tool at the right, known as a "conical point micrometer," has a reduced point and is for measuring the depth of a V-groove.

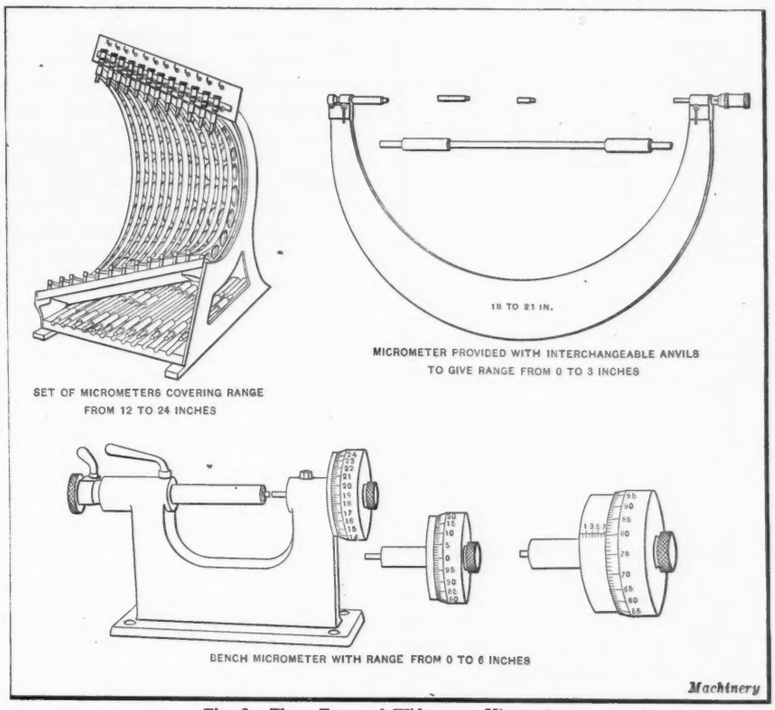
SET OF MICROMETERS COVERING RANGE FROM 12 TO 24 INCHES
18 TO 21 IN.
MICROMETER PROVIDED WITH INTERCHANGEABLE ANVILS TO GIVE RANGE FROM 0 TO 3 INCHES
BENCH MICROMETER WITH RANGE FROM 0 TO 6 INCHES
Machinery

Fig. 8. Three Types of Wide-range Micrometers

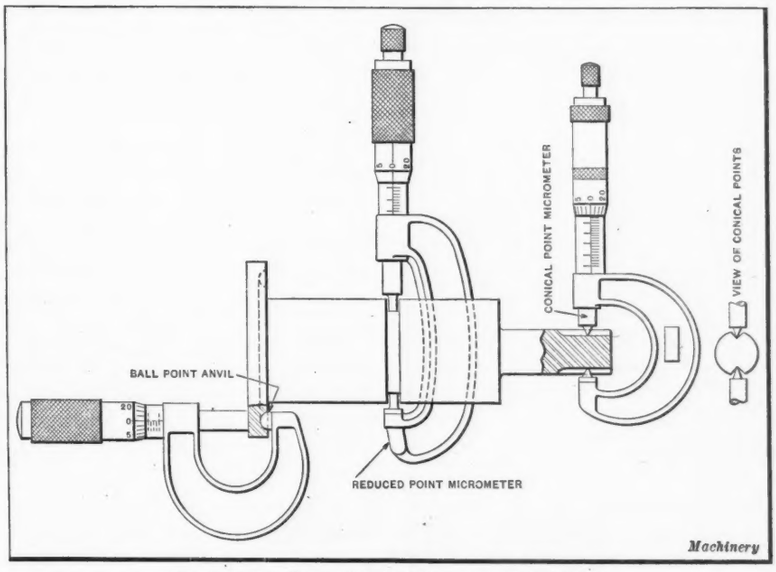

Fig. 9. Three Types of Micrometers with Special Points

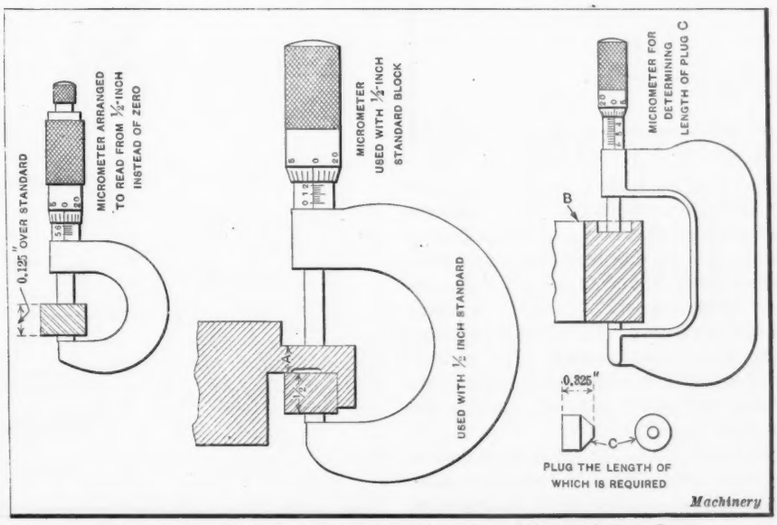
0.125" OVER STANDARD
MICROMETER ARRANGED TO READ FROM ½ INCH INSTEAD OF ZERO
MICROMETER USED WITH ½ INCH STANDARD BLOCK
USED WITH ½ INCH STANDARD
MICROMETER FOR DETERMINING LENGTH OF PLUG C
0.325"
PLUG THE LENGTH OF WHICH IS REQUIRED
Machinery

Fig. 10. Micrometers that take Readings from Some Other Point than Zero

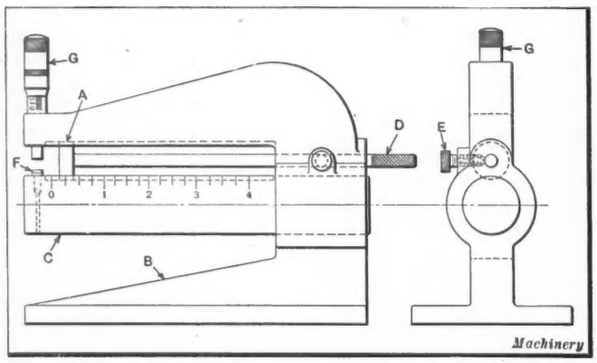

Fig. 11. Micrometer for measuring Thickness of Tubing at Intervals of One Inch

A method of using a micrometer which is not in very general use but which has considerable to commend it is illustrated in Fig. 10. The micrometer reads from some predetermined point and not from zero, as is usually the case. To illustrate this method reference is made to the view at the left. Between the measuring points of the micrometer a block which measures 0.125 inch is shown, and it will be seen that the reading on the tool is 0.625 inch, which indicates that the base of this system (as it might be called) is 0.500 inch. The value of this reading comes from the fact that the piece measuring 0.125 inch is to be used in connection with another piece which measures 0.500 inch. As the two are to be measured independently, it is desired to ignore the other piece which measures 0.500 inch but still get the complete reading, which

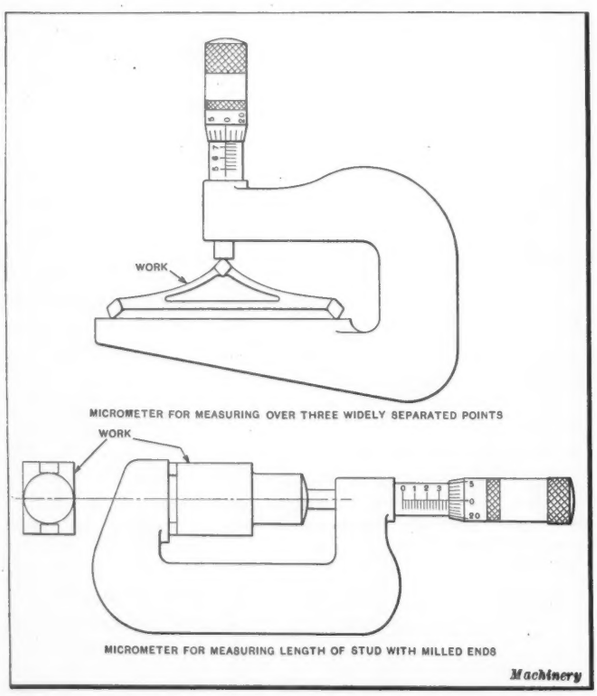
WORK
MICROMETER FOR MEASURING OVER THREE WIDELY SEPARATED POINTS
WORK
MICROMETER FOR MEASURING LENGTH OF STUD WITH MILLED ENDS
Machinery

Fig. 12. Micrometers with Wide Anvils to afford Support for Work

is the length of a plug that must be made to go in a hole 0.500 inch deep and stand out above this hole 0.125 inch. Referring to the view in the center of this illustration, a working application of this system is shown. In this instance it is desired to measure the thickness through *A*, and to do this it is obviously necessary to use a block that will allow the measurement to be taken in the manner shown. For convenience, this block is called 0.500 inch or ½ inch standard. The micrometer is made to ignore this ½ inch standard in taking the measurements, thus giving the exact reading through the wall *A* without any figuring.

In the example shown in the view to the right, it is desired to measure the length of a small plug *C*. The space filled by block *B* plus the plug length is predetermined or standard; thus to find the exact length of the plug, the micrometer is made to read backward from this predetermined figure, automatically giving the length of the plug which it is necessary to make to fill the space. In this instance the space it is desired to fill would be marked zero, and as the measurement being taken on the block is less than zero, the tool reads minus to give the desired length. A special micrometer for measuring lengths and thicknesses of tubing is illustrated in Fig. 11. In using this tool the sliding bar *A* is first placed on an indicating line at zero and the first measurement taken in the usual manner; bar *A* is then moved to the next line and the reading again taken; in like manner, the bar is alternately moved as measurements are taken by the micrometer head, and thus thicknesses at various points from the end of the tube are obtained. This tube micrometer consists merely of the base *B* and anvil *C* over which the tube is slipped, and a

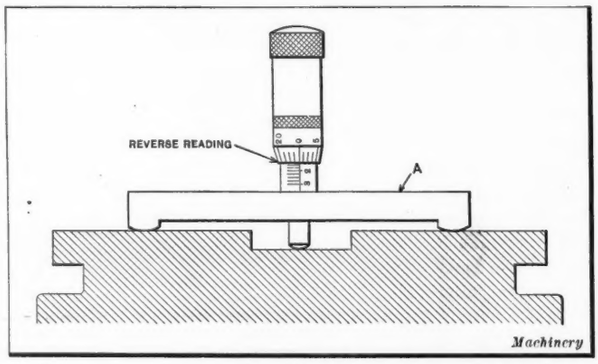

Fig. 13. Micrometer with Reverse-reading Head for measuring Depth of Slot

long bar *D* which is clamped in the correct position by screw *E*, while the measuring point *F* and micrometer head *G* complete the outfit.

In the upper view of Fig. 12 is shown a micrometer for measuring over three points; the frame of this tool is of special form with a long anvil ground at right angles to the measuring head. The manner of using this tool is obvious, but one point that might possibly be overlooked requires specific mention. In a number of micrometers on the market, the adjustment for wear of the measuring point is obtained by moving a screw in the anvil, but in the tool here described it becomes evident that this method of adjusting would not do; therefore, care is necessary in the selection of a micrometer head for this purpose, and one should be obtained where the adjustment is made in the head itself. Referring to the lower view, Fig. 12, a micrometer of similar construction to the fore-

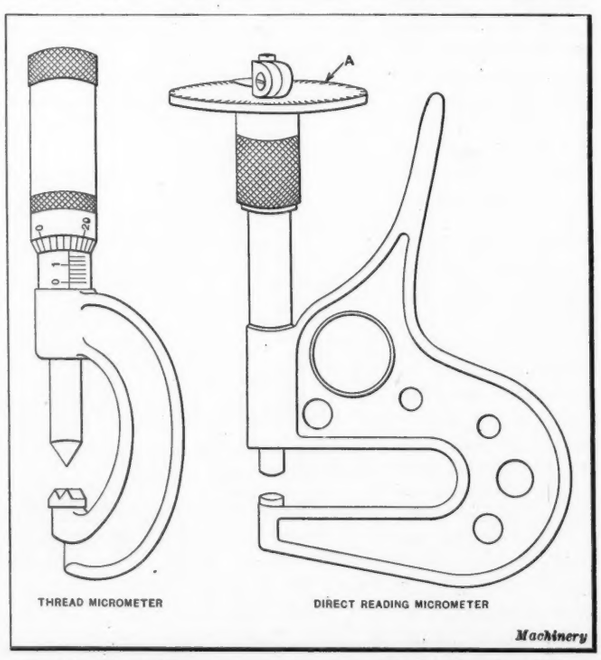

Fig. 14. Thread Micrometer and Micrometer with Direct-reading Dial A

going is shown. This tool is for measuring a stud which has the ends milled to shape. The micrometer needs no special description, as it is simply made to straddle the lugs of the work.

At the left in Fig. 14 a thread measuring micrometer is illustrated. This tool is a well-known type, having a V-shaped lower anvil and a conical pointed upper anvil. To the right a direct-reading caliper is shown; this tool has a large disk *A* from which the measurements are read off directly, without reference to lines on the sleeve as in the regular micrometer. This tool is shaped so that it can be held conveniently in one hand. A micrometer that measures the depth of a groove is shown in Fig. 13. It consists of a bar *A* that straddles the groove and bears on the finished surfaces of the work. This bar is held firmly in position by one hand while the micrometer point is brought into contact with the bottom of the groove in the usual manner, when the reading is obtained direct by having the reading reversed as previously described. The remarks on having the adjustment for wear in the head of the tool apply with equal force to a tool of this type. In connection with this tool it might be well to emphasize the fact that if too much pressure is applied while taking measurements of this kind, the bar would be raised clear of the surface from which the measurement is being taken, and in consequence, a false reading would be obtained.

Fig. 15 clearly illustrates the construction of the friction stop as applied to the head of the micrometer. This consists of a coiled spring inside a sleeve, the former being attached to the screw of the micrometer. The large end of the spring is not held in any manner; therefore, in turning to the right, as in taking a measurement, the thimble of the tool will slip over the spring when the screw comes in contact with the part being measured, while in turning the thimble to the left the spring is uncoiled, thereby causing a binding action between the spring and the thimble which causes the screw to be moved with the thimble. In the lower part of this illustration, the outside appearance of the friction head is shown, and a complete micrometer having a friction thimble is also illustrated. This friction thimble is operated in the same manner as a friction stop, the upper portion of the thimble being made to move independently of the lower portion upon which the reading is taken.

A rather interesting example of micrometer measuring is shown in Fig. 16. In this instance the work being measured is placed on a pin *A* and the measurement *B* is taken by having lug *X* come in contact with the anvil *C;* then by taking a measurement with the micrometer head *D* as usual, the desired reading is obtained. From the foregoing it will be evident that the micrometer when applied to measuring special parts has possibilities that are not limited to any particular sphere and can be applied more effectively in many instances than would be possible if using a fixed measuring gage; one

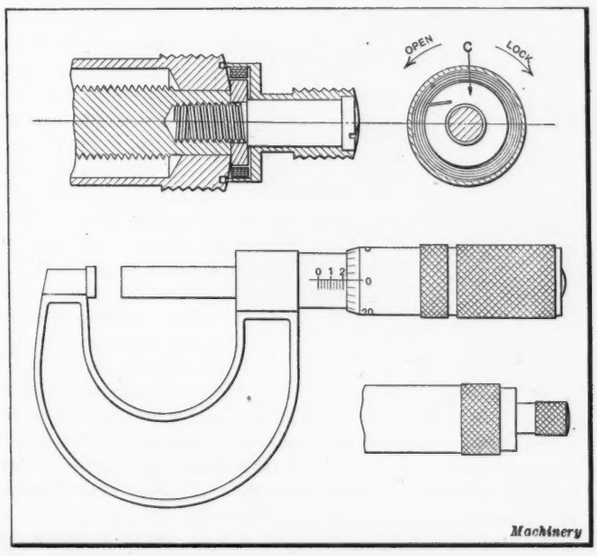

Fig. 15. How Friction Stop is applied to Micrometer Thimble

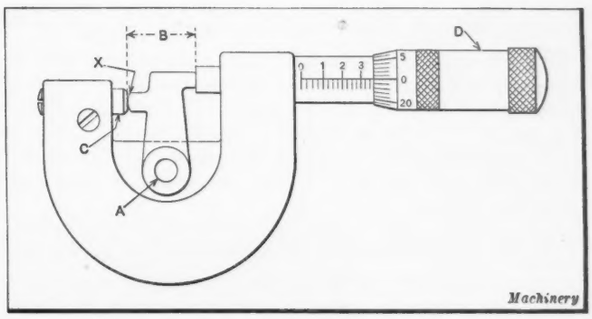

Fig. 16. Micrometer for obtaining Dimension B of Small Lever

advantageous feature of a micrometer is the fact that the screw can be run back to take a reading when making a rough cut, thus enabling the operator to determine the exact amount of stock that has to be removed.

* * *

NATIONAL FRENCH TRADEMARK

A member of the Chamber of Commerce in Paris, M. Raynald Legouez, some time ago started a society known as "L'Union Nationale Inter-Syndicale des Marques Collectives," the members of which society are entitled to place on goods and articles produced by them the trademark "Unis—France," the word "Unis" having been formed by the initials of the first four words in the name of the society. The object of the society is to make it practically necessary for every French manufacturer to become a member, so that all products that do not bear the trademark "Unis" will immediately be marked as either imported or manufactured by other than French makers in France. If the manufacture is of purely French origin, there is nothing to prevent anyone from obtaining the right to use the trademark, but goods that are not entirely manufactured in France, and apparently those that are not manufactured by French capital and labor, may not use the trademark. One of the leading French trade papers, *L'Exportateur Francais*, has decided not to accept any advertisements nor open its columns in any form to any manufacturer who does not belong to the trademark society.

There is apparently good reason for this step having been taken in France in order to prevent abuses by German interests after the war. According to an article in *Industritidningen Norden*, Stockholm, German manufacturers realize that after the war their products will not be especially desirable in the world's markets, and the manufacturers of the Central Empires, according to statements published in the Swedish press, have already made efforts to plan arrangements whereby after the war their products can pass in the world's markets under the names of other nations. Thus, for example, some German firms have already installed branches in Sweden, the object of which is to assemble machine parts made in Germany, so that in this way Herr Schultze and Herr Meyer may be able to sell their goods in the world's market as of Swedish origin. No doubt the same methods will be pursued elsewhere. For this reason, the adoption of a trademark similar to the French is now advocated in Sweden. French importers are already extremely suspicious of articles imported from neutral countries, and it is stated that they have every reason to be so, because they have unintentionally been buying products from the Central Empires at times, and as trading with the enemy is not only illegal, but in addition carries with it the risk under present conditions of loss of customers, great care is taken in France to prevent the importation of articles the origin of which is not well known. It is stated that German newspapers, recognizing the danger of national trademarks, have already begun to advocate as one of the conditions of peace that national trademarks should be forbidden. It is not likely, says the Swedish journal from which the above information is obtained, that the rest of the world will be willing to permit the pan-Germans to dictate the conditions of peace, but this particular condition shows clearly what methods they are already planning for the economic war that they expect will follow the present political war.

BROACHING TEETH OF INTERNAL GEARS

The following article describes the work of broaching the teeth of internal gears on one of the No. 3 broaching machines built by the Lapointe Machine Tool Co., of Hudson, Mass. The gears to be broached were 10.666 inches pitch diameter with sixty-four teeth of 6 pitch; and the forgings were made from alloy steel. The teeth to be broached were 1⅛ inch long and the difficulty consisted of designing a fixture to broach these teeth so that when the entire operation had been completed the teeth would mesh perfectly with the pinion and the whole forging would not be distorted. It will be seen from Fig. 1 that the fixture consists of a main casting *A* bolted to the faceplate of the broaching machine. On the inside of this casting there is a cast-iron part *B* which acts as a guide and support for broach *C*. Carried in support *B* is a hardened steel plate *D* which is a loose fit in the holder. This plate is milled on its under side to fit a taper seat in support *B*, and as the broach is drawn through the work, plate *D* is held in its seat and maintains the broach in the proper position to cut teeth of the desired depth. When the return stroke of the broach is started, plate *D* is pushed back in its taper seat and falls out of guide *B*, thus allowing the broach to drop down out of contact with the work.

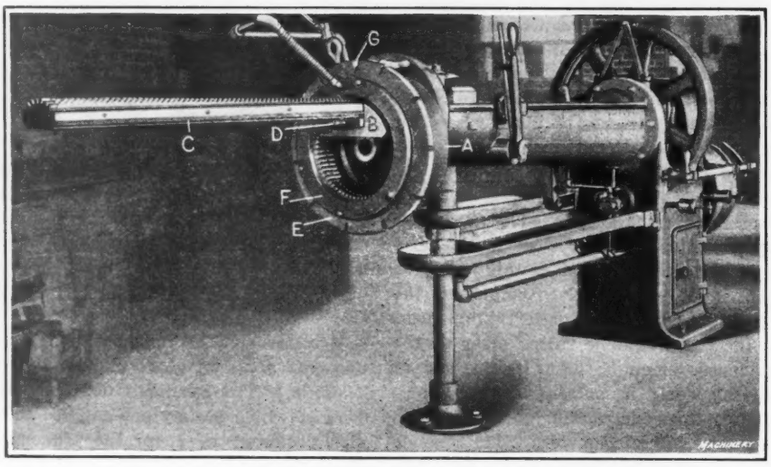

Fig. 1. Lapointe No. 3 Broaching Machine equipped for broaching Teeth of Internal Gears

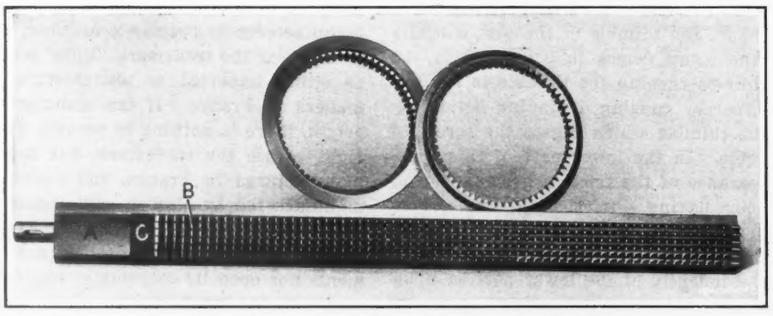

Fig. 2. Close View of Broach and Two Gears broached on Machine

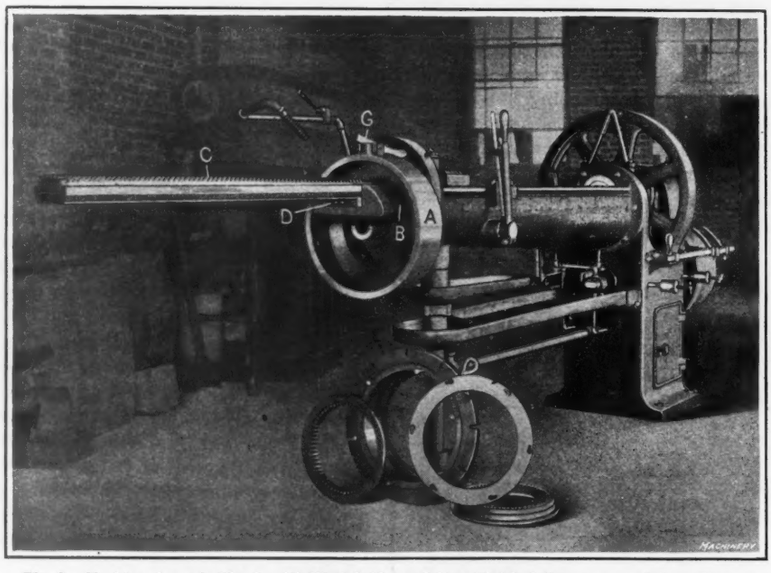

Fig. 3. Machine shown in Fig. 1, with Work-holder and Two Finished Gears removed from Fixture

In broaching internal gear teeth with this equipment, three gear blanks are set up in holder *E* and the blanks are secured in the holder by ring *F*. It will be seen that there are six clamping bolts in holder *E*, which provide for clamping ring *F* in place. In order that the clamping bolts will only have to be loosened, holes are provided in ring *F* of sufficient size to pass over the heads of the bolts, after which the ring is given a slight turn to the right, which results in sliding the bolt heads over slotted extensions of the holes. The bolts can then be tightened to secure ring *F* and the work in place. Reference to Fig. 2 will make it apparent that the broach consists of a frame *A* in which are mounted six broaches *B*. As there are sixty-four teeth in these gears and each passage of the broach through the gear results in cutting six teeth, it will be apparent that eleven passes of the broach are necessary in order to complete cutting the teeth. To provide for indexing the work, it will be seen that holder *E*, Figs. 1 and 3, has eleven slots milled in its periphery, which are tapered on both sides so that latch *G* will index the work accurately when it drops into one of these slots.

In deciding upon the use of a broach of the type shown in Fig. 2, the idea was to provide for the replacement of broken broaches at a minimum expense. Should it happen that a tooth in one section of the broach is broken, this section can be replaced at far less cost than making a complete new broach. These broach sections are first planed to standard dimensions and then drilled in four places so that the entire set of six broaches can be bolted into the frame, which is carefully milled to the right width and depth to receive them. At the left-hand end of the frame in Fig. 2, it will be seen that there is a piece of steel *C* inserted for the broached sections to rest against. These sections are shouldered at the ends so that they fit under piece *C*, provision being made in this way for holding the head ends of the broach sections firmly down in the frame. After the sections have been made, they are put into the frame and bolted in place, so that all sections are drawn firmly together to form the equivalent of a single piece. It is then necessary to turn the outside of the broach sections to the proper radius of curvature and also to cut the teeth. After this has been done, transverse slots are cut to form the cutting edges. The broach sections are then taken out of the frame, hardened and ground on the sides, after which they are once more assembled and ground on the faces and tops of the teeth to obtain the desired height and thickness for the teeth.

In operation, three gear blanks are set up in holder *E* and clamped in place by tightening the bolts over ring *F*. The

entire work-holder is then placed in body *A* of the fixture, and latch *G* is inserted in one of the notches in work-holder *E*. Broach *C* is next connected with the draw-head of the machine, and support *D* put in place under the broach. The machine is now started and pulls the broach through the three gear blanks, any standard cutting compound being used as a lubricant. The machine is next reversed and plate *D* is pushed out to allow the broach to drop clear of the work. The work is then indexed by lifting latch *G* and turning work-holder *E* sufficiently to allow the latch to drop into the next notch. Eleven successive operations of this kind complete broaching the teeth, and, of course, three gears are broached simultaneously. The speed of operation naturally depends somewhat upon the skill of the operator in setting up and removing the gears, but a production rate of nine gears per hour has been attained by an unskilled operator. The special fixture required for this job was designed and placed in operation by H. E. Blanchard, works manager of the Lapointe Machine Tool Co. E. K. H.

* * *

COMPENSATION FOR INJURIES OBTAINED IN EMERGENCIES

BY CHESLA C. SHERLOCK[1]

It is well settled that so long as an employe is within the scope of employment he is entitled to compensation in case of injury; but let the workman leave his employment or get outside its scope and he is not entitled to compensation if injury results. This line of demarkation between acts within the scope of employment and those outside is a very fine one, and many nice questions come up every day in industrial centers upon this point. Heretofore, the workmen's compensation acts have been discussed as they apply to cases where the injured workman suffered his injury in the course of his employment. It is equally interesting and serviceable to know under just what circumstances compensation is payable for injuries received when the workman has gone outside the scope of his employment and received an injury.

Even though the rule that an employe is not entitled to compensation for such injuries seems to be grounded firmly in common sense and in good legal reasoning, the courts have allowed compensation in a certain line of cases. They have said that even though the rule is that a workman is not entitled to compensation if he gets outside the scope of his employment, compensation will be allowed him if he was forced to leave the scope of his employment because of an emergency. This does not mean that an ordinary set of circumstances will suffice to throw the mantle of legal protection over the workman's shoulders. It means clearly that the situation which makes cases of this nature compensable must have been one of extraordinary emergency, of unusual peril, or one dictated by humane thought and action.

The Illinois Supreme Court has decided a case that well illustrates the point here made. A workman, engaged in different kinds of work in his employer's plant, was working on some safety devices when an employe working on some steam pipes under the floor, in which an opening had been made but which it was impossible to see because of the escaping vapor and steam, slipped and fell through the opening into the hot water, screaming for help. The first employe dropped his work and ran toward the hole, but owing to the steam obscuring it, fell in and was so badly scalded that he died. The court held that the deceased workman was entitled to compensation for the reason that the emergency justified his act and that, although under ordinary circumstances he would have been outside the course of employment, he was covered in this instance. One of the earliest decisions of the California Commission held that an employe in attempting to escape from a danger incident to his employment is acting in the course thereof and is entitled to compensation.

In a New Jersey case, a workman slipped and fell, sustaining injuries which later resulted in his death, in trying to dodge a blow aimed at him by a fellow workman in a spirit of sport. The court said: "The trial judge found, as a fact, that the decedent did nothing to invite the attack and it is not denied that the decedent was acting, at the time, within the scope of his employment. It is a matter of no consequence whether or not the workman, at the time he made the attack, was acting within the scope of his employment. In the case under consideration it appears that the prosecutor employed young men and boys. It is but natural to expect them to deport themselves as young men and boys replete with the activities of life and health. For workmen of that age, or even of maturer years, to indulge in a moment's diversion from work to joke with or play a prank upon a fellow workman is a matter of common knowledge to everyone who employs labor. At any rate, it cannot be said that the attack made upon the decedent was so disconnected from the decedent's employment as to take it out of the class of risks reasonably incident to the employment of labor.

"At common law, the master was not liable for an injury to his servant caused by the negligent act of a fellow servant upon the ground that the servant assumed the risk. Under the workmen's compensation act, the master assumes all risks reasonably incident to the employment. It was a negligent act of the fellow workman to make a pass at the decedent while passing him on the slant of the concrete floor, and for such negligence the master would not have been liable at the common law, not upon the theory that it was not a risk reasonably incident to the employment, but upon the ground that it was a risk which the servant assumed when he entered into his master's employ." The court sustained the award of compensation made by the lower trial court.

In a Californa case, a workman was killed while attempting to rescue fellow workmen who had been imprisoned by a cave-in of dirt. His employers defended on the ground that he was guilty of wilfull misconduct in going back into the tunnel in an attempt to rescue his fellow workmen when he had been warned of the danger. The commission held that the dependents of the deceased were entitled to compensation, saying, "The deceased was the only one of the employes who responded to the call of his fellow workmen for help and he lost his life in the effort to effect a rescue. Such conduct is not misconduct, much less wilfull misconduct. Even though he deliberately exposed himself to the danger of injury and death, his action cannot be said to be wilfull in the sense of being stubborn, perverse, or as evidencing a state of mind opposed to the orders and instructions given him, or as opposed to the action that reasonably should have been taken by him, both as a fellow employe and in his official capacity as an assistant foreman."

In another case decided in the same state, the court held that where an employe is present at the scene of the death by accident of several of his fellow employes while they are working upon the premises of the employer, and where such employe attempts to aid in the rescue, and becomes insane as a result of the mental and emotional shock incident to the excitement, peril and sense of duty to aid in the rescue of his co-workers, such accident is a disability caused by accident. Compensation was allowed on the theory mentioned before, namely, that an act done in an emergency is not outside the course of the workman's employment. In one case, a workman ran to a telephone to summon aid for an injured fellow workman. After reaching the telephone he was seized with an apoplectic shock, which resulted in his own death. Compensation was awarded, the court saying that it was within the duty of a workman to summon aid for a fellow employe, although not specifically mentioned to him or expected in ordinary circumstances.

Employers should bear this point of law in mind, as it will very often take a case out of the non-compensable class and make it compensable. The rule is that if the workman acts in a sudden or extraordinary emergency and is injured, he is entitled to compensation.

* * *

The International Association of Industrial Accident Boards reports that 80 per cent of the injured soldiers and sailors of the Allied Nations are enabled through re-education to take up gainful occupations.

[1]Address: Box 253, Des Moines, Iowa.

DAYLIGHT FACILITIES IN INDUSTRIAL PLANTS

FACTORS GOVERNING AMOUNT OF LIGHT TRANSMITTED THROUGH WINDOWS

BY C. E. CLEWELL[1]

ONE of the most fundamental and important problems in the modern industrial plant is that relating to adequate daylight throughout the normal working hours of the day. This is apparent at once from the following considerations: (a) Sufficient daylight for every employe is a primary requisite for the best workmanship; (b) the factory floor space that is well lighted throughout, has a higher value from the manufacturing point of view than the floor that is only partially lighted, and in which certain spaces are too dark to carry on good workmanship; and (c) the plant that is sufficiently provided with natural light during the daylight hours is saved the expense for artificial light during portions of the day. While these phases of the problem are obvious, there are a number of elements in the daylighting problem that are not generally understood and appreciated. One of the chief objects of the present article is to outline some of the more or less fundamental aspects of the case and to follow these up with brief references to modern American practice in window planning. Some typical plants equipped with recent developments in window sash construction are shown in the illustrations.

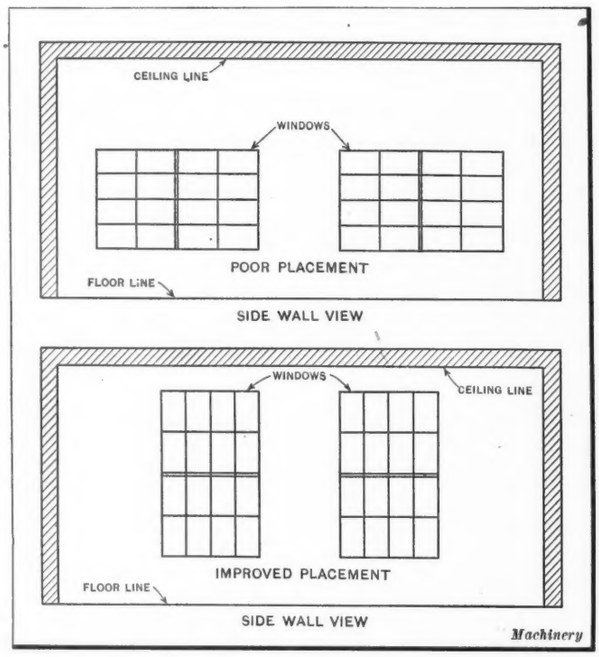

Fig. 1. Illustrating Importance of Arrangement of Window Openings

There is a tendency to look upon large window area as the one requirement to be met in successful window planning. As a matter of fact, the area of the window openings is only one of a number of points that should receive careful consideration in the plans for new factory structures. In other words, a given ratio of window area to floor area, which may be entirely satisfactory in one plant, may not be an adequate arrangement under different conditions. To illustrate this point, two side walls are shown in Fig. 1, in which the window openings have exactly the same area. In the upper part of the diagram, the windows are placed horizontally with a considerable distance between the upper part of the sashes and the ceiling line. In the lower part, the windows are located vertically with the top of the windows near the ceiling line, and it is evident that the latter arrangement is preferable, since the light through the higher windows will reach more remote portions of the floor space in the building. As a first important conclusion, therefore, it follows that the arrangement of the window openings, as well as their area, must be given due weight in factory planning. Fig. 1 merely illustrates the point, the principle being applicable to actual cases found in practice.

Dependence of Transmitted Light upon Angle of Incidence

The most favorable condition for effective lighting is usually that in which each side window receives throughout its entire area the unobstructed light from the sky. Put in a slightly different way, the ideal condition is where an unobstructed view of the sky is obtained from any part of the interior floor space throughout the entire area of each window. Even in such cases, however, much of the light which is incident upon the front surfaces of the windows strikes the glass at rather large angles with a line perpendicular to the glass surface. These angles, as illustrated in Fig. 3, are termed the "angles of incidence." For plain window glass, the maximum amount of light is transmitted into the building when the light strikes the window surface squarely; that is to say, when the angle of incidence is zero. Under this condition, all the incident light save that absorbed by the glass itself is transmitted into the building, this absorption being placed at about 10 per cent by Marks in his lecture before the Illuminating Engineering Society and the Johns Hopkins University in 1910. The same authority shows that for increasing angles of incidence the percentage of light transmitted into the building falls off quite rapidly, particularly after 60 and 70 degrees are reached, as shown in Fig. 2. It will be evident that when the light grazes the surfaces of plain glass at such high angles, much of the light will be reflected away from the glass rather than directed into the interior. For this reason it is often found advantageous to use some special form of roughed, ribbed or prism glass where most of the light reaches the windows at high incident angles, since these special glasses are capable of redirecting a larger proportion of the light into the building than is possible when plain glass is used.

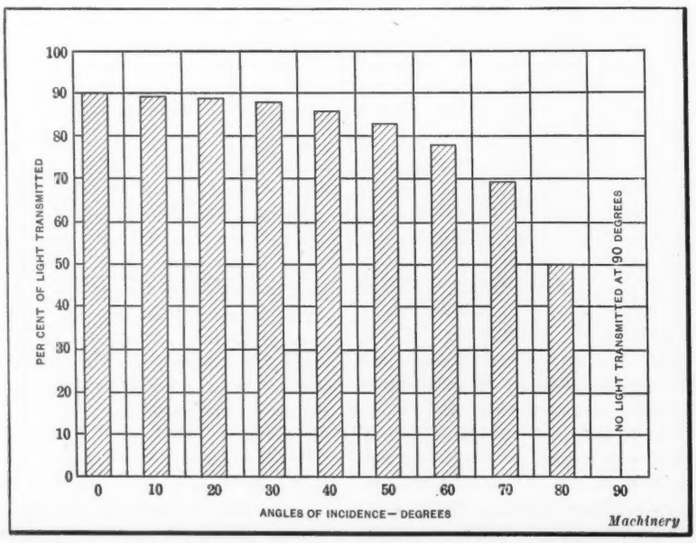

Fig. 2. Chart showing Percentages of Light transmitted into Building for Various Angles of Incidence

From what has just been stated, it will be apparent that the most favorable condition for the use of plain glass is where the windows face an unobstructed horizon. This very favorable condition, however, is often defeated by the presence of nearby buildings that cut off a large part of the sky. In such a case, two facts should be not-

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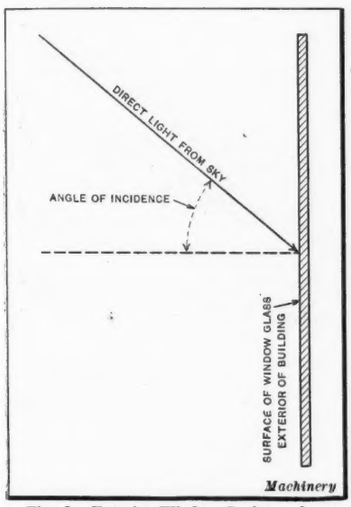


Fig. 3. Exterior Window Surface, showing Angle of Incidence

ed. One is that for most parts of the factory interior, the adjacent building may make it impossible to see the sky through more than a fraction of the window area. The second is that the adjacent building causes most of the light that reaches the windows to come down between the buildings from the sky, and hence involves large angles of incidence, as defined by Fig. 2. In the first case, the reduced visible area of window through which sky is visible causes a direct loss in the effective window area available for lighting, since that part of the window through which sky is not visible from any given point in the factory becomes useless in its lighting effect for the given point, unless the opposite building front is light enough in color to reflect some of the light from the sky across and into these otherwise useless portions of the window areas, in which case the effect is of course less than that due to direct light from the sky. This statement refers primarily to plain window glass. If these relatively uselss window areas are equipped with roughed or prism glass, they may then be utilized in spite of the fact that most of the light is received from overhead sky.

Extreme Variations of Exterior Daylight

It is not always realized that the variations in the intensity of natural light under the open sky are great throughout a given day and for different seasons of the year. Fig. 4 shows graphically typical variations from 5 A. M. to 7 P. M. in June, September and December based on tests in Great Britain by a departmental committee on the lighting in factories and workshops, appointed by Parliament. The intensity values used as ordinates for these curves are expressed in the now commonly accepted unit known as the foot-candle. To understand these curves it is to be noted that the "foot-candle" is the unit of illumination and is defined in the factory lighting code of the Illuminating Engineering Society as the lighting effect produced upon an object by a standard candle at a distance of one foot. At two feet, the effect would be one-fourth instead of one-half foot-candle, since the intensity varies inversely as the square of the distance between the source and the object lighted. Therefore, a sixteen candlepower lamp—one that gives off sixteen candlepower in all directions—will give a uniform illumination of one foot-candle at a distance of four feet in any direction. The actual values of the intensity represented by the curves in Fig. 4 will be better appreciated when

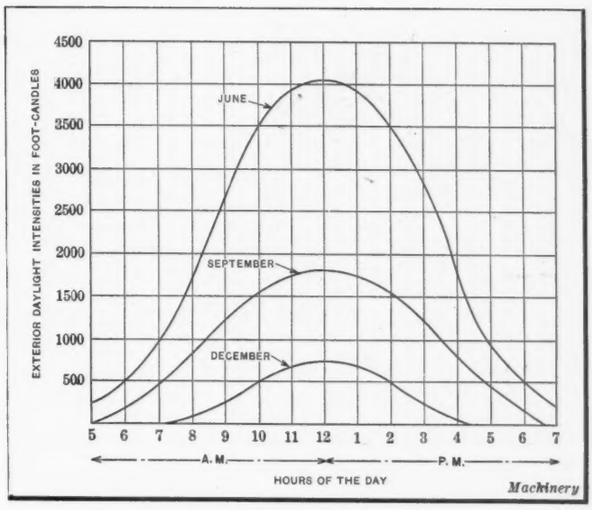


Fig. 4. Curves of Exterior Daylight Intensities

it is considered that for rough manufacturing work a satisfactory intensity of artificial illumination usually ranges from about two to four foot-candles. It is apparent, therefore, that the usual intensities of exterior daylight are large in comparison with the intensities that are considered satisfactory for factory interiors when supplied with artificial light, and also in comparison with the actual interior intensities of natural light as explained below. Special attention, furthermore, is directed in these curves to the differences in the intensity at the same hour for typical days in June, September and December. Thus at noon on a June day it may have a value somewhat over 4000 foot-candles, while at the same hour on a typical December day it may be about 750 foot-candles, or less than one-fifth as much. Note also that the values are very low even as late as 8 and 9 A. M. and quite early in the afternoon on December days.

Ratio of Interior to Exterior Illumination

An interesting study may be made of probable interior values of daylight illumination for given exterior conditions, if a fairly definite idea is gained of the relation existing between interior and exterior intensities at any given time of day. The differences between the interior natural light of a factory and the corresponding exterior conditions out under the open sky are likely to be far greater than is ordinarily appreciated, and as such differences depend greatly on the arrangement of the windows and other conditions connected with the daylight problem, we shall now turn briefly to this phase of the subject. It is a fairly simple matter to obtain a numerical value for the ratio between the daylight conditions at a point within a factory and the conditions without under the open sky. Thus if simultaneous measurements are made of these two intensities, we may divide the interior intensity by the exterior value, expressing the result as a percentage, and obtain in this way a numerical measure of the effectiveness

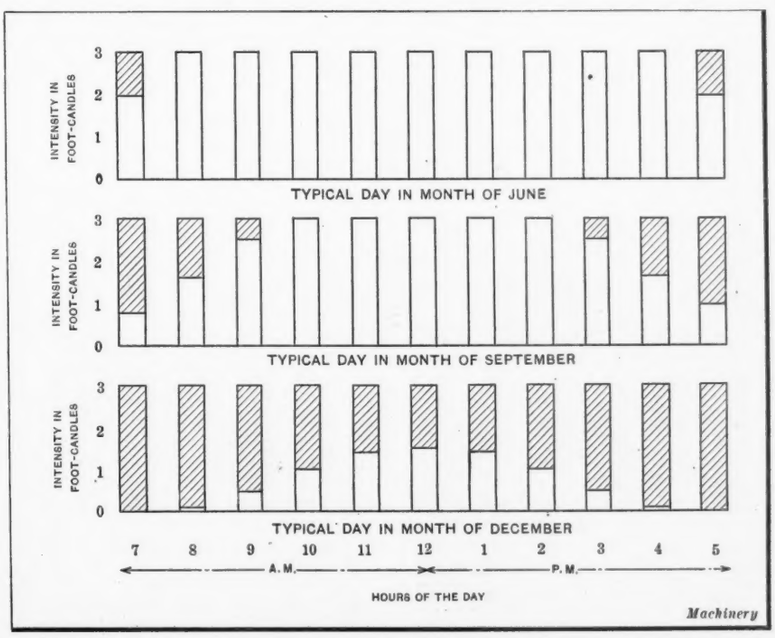


Fig. 5. Chart based on Fig. 4, showing Hours when Daylight Intensities within Buildings will produce Three Foot-candles at Points within Daylight Factor

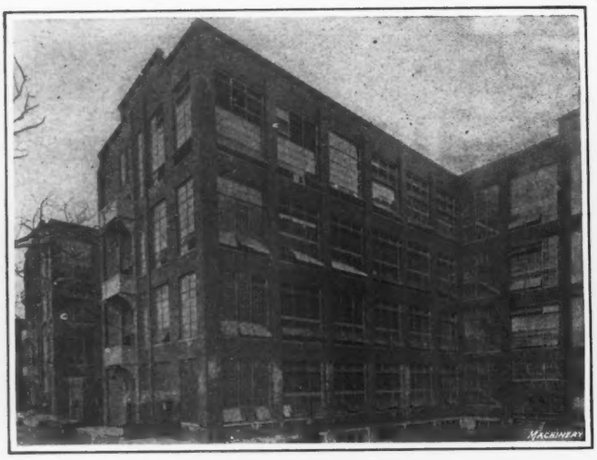


Fig. 6. Exterior View of Plant, showing Top-hung and Centrally Pivoted Steel Sash

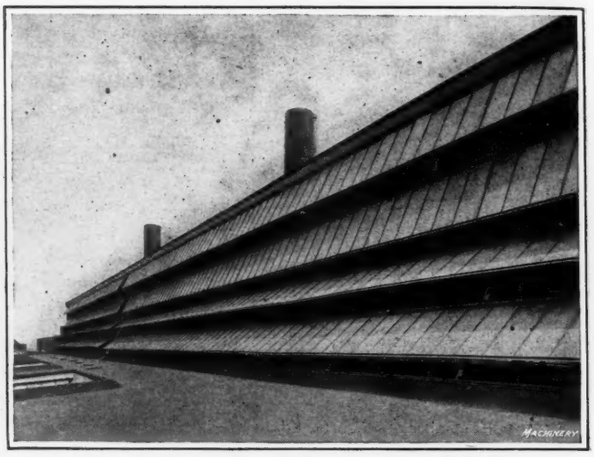


Fig. 7. Exterior View of Factory equipped with Top-hung Continuous Steel Sash

of the windows in lighting the interior. This ratio has been given the name "daylight factor" in the British report referred to. A building with adequate window areas and with no obstructions nearby to cut off the sky, will tend to have a relatively high daylight factor for all points over its floor area; whereas a building with inadequate window area and many surrounding obstructions will ordinarily have a low daylight factor for many if not all of the points throughout its floor space.

The tests in Great Britain to ascertain the value of the daylight factor show that it usually has very low values. In a few cases it reaches 10 per cent, and the mean values for a large number of factories ranged roughly between 0.25 and 2 per cent. It follows, moreover, that for points near the center of a building, which are remote from windows, this factor may be much lower than for points near the windows. In fact, at points near the center of some work-rooms, which depend entirely upon side windows (that is to say, with no roof lighting) this factor has been found to fall below the ranges given above, sometimes being as low as 0.01 per cent, which means that the light reaching such points is only one ten-thousandth of the value existing outside the building.

Application of Daylight Factor

Investigations with reference to this factor in industrial plants have shown that its value is practically constant at all times of the day and at the different seasons of the year. Hence, if its value is known for representative points within a factory, and if the exterior daylight variations are at hand for the geographical location in question in a form similar to the curves of Fig. 4, we may then determine approximately at what hours of the day the daylight will probably fall below any prescribed minimum intensity. To illustrate this point, it has been assumed that the daylight factor at a point in a factory has a value of 0.2 per cent. On a typical June day at 7 A. M. the curves in Fig. 4 show the exterior intensity to be about 1000 foot-candles. For the given daylight factor of 0.2 per cent, the interior intensity at the given point will then have the value $1000 \times 0.002 = 2$ foot-candles. Let us assume that the minimum value of the illumination for satisfactory work is 3 foot-candles. Then at 7 A. M. on June days, with 2 foot-candles at the work due to daylight, artificial light will be necessary if the prescribed minimum of 3 foot-candles is maintained. In Fig. 5, in the upper left-hand corner, the conditions at 7 A. M. on a June day are shown graphically. The total area represented is 3 foot-candles, of which 2 foot-candles (the unshaded part of the area) are supplied through the windows. At least one additional foot-candle (the shaded part of the area) must be supplied in the form of artificial light to bring up the illumination to the prescribed minimum of 3 foot-candles. At 8 A. M. the curve in Fig. 4 shows the exterior daylight intensity on a June day to be about 1750 foot-candles. This means an interior intensity due to daylight of 3.5 foot-candles for the given daylight factor of 0.2 per cent. Hence the daylight intensity at the given point is greater than the prescribed minimum by 0.5 foot-candle, and the area of 8 A. M. in Fig. 5 is shown unshaded throughout to indicate that no artificial light is required at this hour.

Points Brought Out by Chart

Fig. 5 illustrates in an instructive and interesting manner the changes that occur within a factory with given windows due to the changes of exterior daylight as indicated by the curves in Fig. 4. It must be remembered in a study of Fig. 5, however, that this chart has been prepared on a basis of one given daylight factor and for one set of curves of exterior intensities. Not only may the exterior conditions at various locations be different from those shown by Fig. 4, but the daylight factor may have values which differ materially from the one assumed in the preparation of this chart. Moreover, the different portions of a given factory floor may have

Fig. 8. Exterior View of Foundry, showing Counterbalanced Type Steel Sash

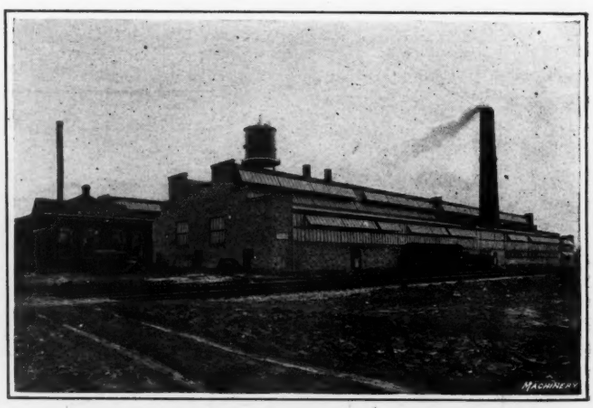


Fig. 9. Exterior View of Building, showing Top-hung Continuous Steel Sash

great variations in the daylight factor, ranging from relatively high values near windows to relatively low values at the center of the building. It should also be kept in mind that the actual changes in intensity throughout a day do not necessarily follow a smooth curve, as in Fig. 4. The passage of clouds of varying density over the sun may cause sudden changes with extreme variations above or below the values indicated by these curves. However, if the daylight factor is determined for the darkest part of a factory interior, and if curves like Fig. 4 are available, it then becomes a fairly simple matter to determine the probable times when artificial light will be required to supplement the natural light during normal working hours of the day and for the worst conditions in the plant. From the standpoint of such a determination, a chart like Fig. 5 becomes of special interest and value, for showing the importance to production of an adequate system of artificial lighting. In Fig. 5 it will be seen that, with the exception of 7 A. M. and 5 P. M., the typical June day has sufficiently large exterior daylight intensities to insure the prescribed minimum intensity at the given point in the factory. In September, the shorter days are evidenced by the need for some artificial light up to 9 A. M. and after 3 P. M. Some artificial light will be necessary under the given conditions throughout the entire day during December, a requirement which is not uncommon for the darker portions of factory floors where the window areas are not adequate.

Ratio of Window Area to Floor Area

As pointed out near the beginning of this article, the area of window openings is only one of the requirements of scientific daylight planning, and the other requirements, some of which have been outlined, should always be given due weight in such plans. It is interesting, however, to note some of the values of the ratio of window area to floor area as found in modern factory practice. Based on the experience of D. Lupton's Sons Co., seven cases have been investigated as representative of typical modern plants. The ratio of window area to floor area ranges in these seven cases from about 19 per cent to about 109 per cent with an average of about 50 per cent. This average value agrees fairly closely with mean values of this ratio for roof-lighted and combined roof- and side-lighted factories based on the extended observations made in Great Britain. Any attempt, however, to arrive at a definite figure for this ratio is limited by the necessity of taking other features aside from area into consideration, and the large ranges in the values of this ratio in current practice indicate that standardization, at least in the present stage of development of the art, is hardly to be expected.

Some idea may be gained of the present tendency to utilize as much of the side wall area as possible for windows, by the experience of the Detroit Steel Products Co., manufacturer of "Fenestra" sash. Figures available from this concern indicate for twenty-two typical cases an average of over 60 per cent for the ratio of side windows to side wall area, the ratio being as high as 90 per cent in some cases. From what has already been said, however, it should be evident that the mere installation of as much window sash as possible is not necessarily a guarantee that the daylighting will be satisfactory unless other factors, which are almost equally important, are given their share of attention when the plans for new buildings are prepared. It is to be hoped that progress in this direction will be such as soon to result in more definite standards for window openings than are now available.

Typical Types of Window Sash Used in Present Practice

To illustrate the practical side of the more or less fundamental principles of the problem just discussed, Figs. 6 to 11 are included. These may be briefly described as follows: Pivoted sash, as it is usually understood, is shown in Figs. 6 and 10. Fig. 6 indicates both the top-hung and the centrally pivoted types, the upper sashes of each window unit being centrally pivoted and the lower line of sash for each unit being top-hung. The use of top-hung sash for the lower sections prevents the sash, when open, from projecting into the building. Fig. 10 is an interior view and gives an excellent idea of the centrally pivoted type with its slight projections into the building, when open. This may be an objection when it is desirable to locate work close to the side walls.

An interesting development is shown in Fig. 8, where the counterbalanced type of Lupton sash is used. When the lower sash is raised for ventilation purposes, the upper sash is lowered a corresponding amount automatically, thus increasing the ventilation and at the same time avoiding any projections into the building as with the centrally pivoted type. The close relationship between the daylighting and ventilation problem has received an unusual degree of attention by certain manufacturers. Perhaps the foremost case of this kind is illustrated by Figs. 7, 9, and 11, which indicate the use of the Pond patented continuous sash (top-hung) as employed with the Pond truss. Fig. 7 is a close view of the continuous sash, showing the long lines of sash used as a unit, the opening and closing of which is accomplished by a special operating device. Fig. 9 gives an idea of the applications of the continuous sash to a finished structure; and the end view of the roof in Fig. 11 shows the effect on the general shape of a partially completed shop through the use of this form of truss, which is designed to improve ventilation as well as lighting.

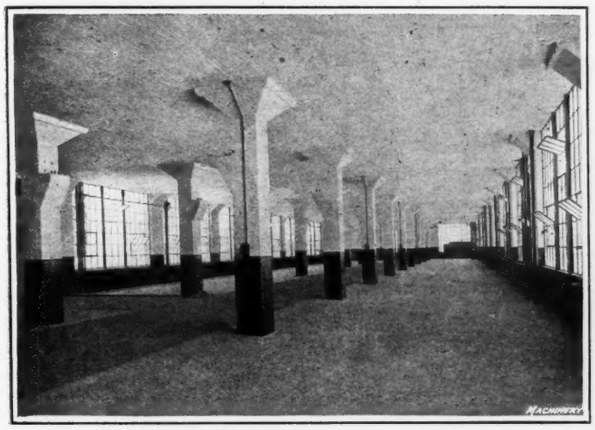


Fig. 10. Interior View of Plant, showing Pivoted Steel Sash

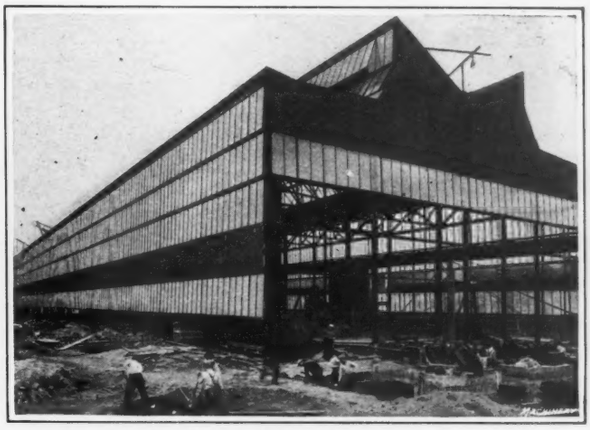


Fig. 11. Exterior View of Building, showing Continuous Sash and Truss

These illustrations will convey the idea of the radical departures which have been made in sash design and construction in comparison with older shop window practice. There can be little doubt as to the many advantages which these improvements in window planning will have on factory methods and production, but at the same time a word of caution is in place that, with the acceptance of these improvements, the other extreme of excessive light and undue glare be carefully avoided. There is the danger that, in the desire to possess the best daylight facilities, undue emphasis may be placed on quantity rather than quality of light, and that other fundamental aspects of the problem may be overlooked. Too much light is as harmful as too little. The illumination of the old gloomy factory is certainly a step in the right direction, and this article does not in any sense discourage these commendable advances. It merely suggests the importance of a realization of some of these other factors.

FILE RENEWING

At this time, when the conservation of materials and the prevention of waste is highly important, the various methods for file renewing, whereby dull files may be restored to their original usefulness, rather than being thrown onto the scrap heap, are of importance. A number of different processes have been developed from time to time for the renewing or resharpening of worn files. One company has put out a machine known as a "file-sharpening machine," which is, in effect, a sandblast. The objection to the sandblast for file renewing is that, while it sharpens the teeth, it does not deepen the groove between the teeth, and hence does not restore the file to its original condition. Another method is the acid dip, consisting of mixtures containing hydrochloric, nitric and sulphuric acids. This will deepen the space between the teeth, but inasmuch as it eats away the tops of the teeth as well as the metal in the groove, it does not restore the file to its original condition, nor does it sharpen it appreciably. The same may be said of the electrolytic method, in which the file to be sharpened is made the anode in an electrolytic bath. A fourth method, which is really only a cleaning method and which does not in any way restore the file, is the wire-brush method, which has been used to a limited extent for file renewing. None of these methods can be said to have been successful in restoring files to a condition equal to new.

The American File Renewing Co., Providence, R. I., is using a method for renewing files which consists more or less of a combination of some of the other methods, whereby not only the grooves between the teeth of the file are deepened, but a sharp edge is also produced on the top. This method was originated in 1902 by August Beran, and is used exclusively by this company and by no one else. The process employed is briefly as follows: The worn-out files, as received from the customers, are first listed; that is, they are provided with some identifying mark on the tang, making it possible to distinguish the files belonging to each customer after they have received the required treatment. They are then graded according to their condition, as files that are badly worn or rusted must be treated differently from those that are less worn and in a reasonably good condition. After the grading, the files go to the cleaning bath into which they are dipped to clean out the dirt that adheres to them. Where chips are wedged firmly between the teeth, these must be afterward removed by picking, which simply consists in using the end of a wire for picking out the material between the teeth. The file is now clean and ready to receive the renewal treatment. A resist which will prevent the acid dip from attacking the tops of the teeth is first lightly applied, so that the tops are covered, but the spaces between the teeth are left uncovered. The files are then dipped into crocks containing solutions that will eat away enough metal in the grooves to produce teeth of the original depth. The length of time that the files remain in the acid dip depends upon their condition, and it is at this time that the proper grading of the files becomes important. When the groove has been made of sufficient depth, the sandblast is used, when required, to produce a sufficiently sharp tooth, and after this the files are covered with a solution or varnish to prevent them from rusting and give them a good appearance.

The advantages of this process are that the cuts are uniformly deepened, so that the teeth are restored to their original length. A good file can be renewed by this process from four to six times; after this, it will be too thin for service. By treating the files by the methods described, a sharp point is produced. In fact, it is claimed that the point is even sharper than in a new file, on account of the absence of the burr that is present when the file is cut with a chisel. The methods of file renewing as practiced by the company mentioned also have the advantage over the recutting methods of not drawing the temper, as the file is not submitted at any time to a heat higher than that of boiling water. In the recutting methods, where the file is annealed and recut, the resharpened file is softened and the metal is not as good as in a new file.

In the accompanying illustrations, Fig. 1 shows an enlarged photograph of a file in the state in which it is received for file renewal; Fig. 2 shows a file that has been cleaned and is ready for the renewal process; while Fig. 3 shows the condition of a file after it has been properly treated. While it is difficult to reproduce in a photograph the exact condition of the file, it may be noticed that the depth between the teeth has been increased and that, instead of the flat or rounded tops of the teeth in Figs. 1 and 2, there is a distinct sharp edge on the teeth shown in Fig. 3.

Fig. 1. Worn Condition in which File is received for Renewal

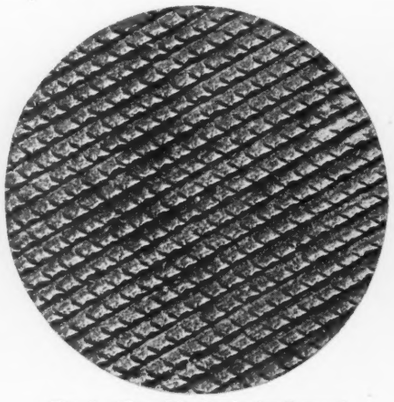


Fig. 2. Worn File Ready for Renewal Process

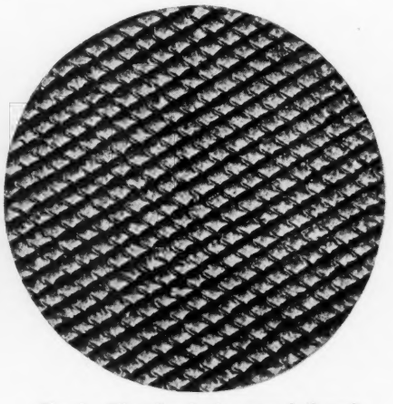


Fig. 3. File after having passed through Renewal Process

The cost of file renewing is enough less than the cost of new files to warrant the use of this process, and at this particular time it is especially important because of the saving of time and material in the production of new files. The American file Renewing Co. makes a practice of charging for the renewal of files in accordance with the original cost of the file. The saving over a new file is over 33 1/3 per cent on American pattern files and up to 50 per cent on toolmakers' files, the charge being made by giving a discount on the list price of new files, so that the cost of renewal is always a definite proportion of the cost of the new file, and in no case more than 66 2/3 per cent.

In the file industry, a peculiar method of discounts is in vogue, which causes considerable confusion and sometimes misunderstanding as to the actual price paid by a customer. For example, one manufacturer may give a discount of 70-10-10-50 and 25, which, while it looks like a very heavy discount, is practically the same as that of 90 and 10. This is something that buyers of files and those who contract for file renewal should take into consideration, so as to determine exactly the cost of new files as compared with file renewal, and also so as to be able to compare the prices charged by various companies engaged in file renewal. E. O.

* * *

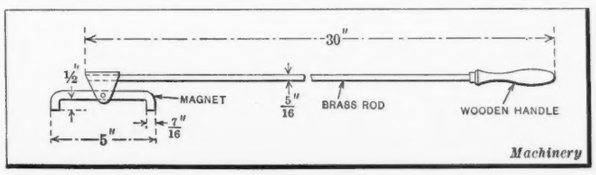
According to a British consul, the production of platinum in Russia last year was only one-third the normal output. This reduced output was due to the scarcity of labor and the difficulty of securing mechanical parts for the dredges.

LETTERS ON PRACTICAL SUBJECTS

WE PAY ONLY FOR ARTICLES PUBLISHED EXCLUSIVELY IN MACHINERY

MAGNETIC TEMPERING DEVICE

As I have seen several magnetic tempering devices advertised at $10 and upward, it has occurred to me that others may be interested in a tempering magnet that I have used for a number of years. The illustration shows the construction, which is very simple, so that the entire device can be made for $2 or $3, including the toolmaker's time. The handle is a 5/16-inch brass rod, 30 inches long; the yoke is of 16 or 18 gage sheet brass, riveted to the handle. The magnet is 7/16 inch square and about 5 inches long over all after being bent, and the two legs are about 1/2 inch long. The hole in the yoke is for a 3/32-inch cotter-pin, and is drilled about 1/4 inch off center. A cotter-pin is used so that the magnet can be easily removed for recharging. The magnet is mounted with the long end toward the handle, and is free to tip up or down about 3/8 inch. The steel companies manufacture a special magnet steel, but the best one that I have had was made from "Novo" high-speed steel. It must be hard and drawn very little. In order to charge, draw the magnet over the pole of a strong electromagnet using direct current,



Magnetic Tempering Device

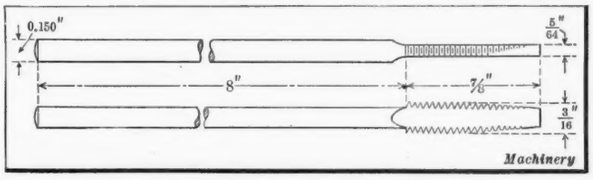
being careful to draw only in one direction. I have used the field of a direct-current motor or dynamo.

When using the magnet, the front leg is placed on the steel as it approaches the proper heat, and if it has not reached the correct temperature, the magnetic pull will lift the rear end up against the handle when the whole thing is raised, but when the correct temperature is reached there will be no attraction, and the magnet will withdraw without tipping. The various parts of the steel may be tested, and if it is not uniformly heated, this will be shown definitely. As high temperature destroys magnetism, the magnet should be kept cool by frequently dipping in water, and should not be held in the furnace long at one time. I believe that anyone who uses this tool will not want to go back to judging temperatures by the eye. In drawing, I use half and half wire solder instead of judging by color. Carbon steel drawn until it will just melt the solder is right for most die and tool work.

Plymouth, Mich. W. B. GREENLEAF

FLAT TAPS

In tapping a 3/16-inch, thirty-six-thread hole in steel 3/4 inch thick, we had considerable trouble with taps breaking when tapping with a short tap, running it in and backing it out of each piece. We therefore made up a flat tap with a shank about 8 inches long. As the flat tap allows plenty of chip room and the long shank acts as a sort of torsion spring, taking up sudden shocks, the taps last several times as long. As a consequence, we are now making all our taps that way, up to 1/2 inch diameter. There is a saving of time, as well,



Proportions of a Small Flat Tap

for the tap is run clear through the piece and is left on the shank until it is full, instead of backing the tap out each time. When the shank is full, it is taken out of the chuck and emptied like a regular nut tap.

Boston, Mass. J. A. SHAND

A MOUSE-TRAP CONVEYOR

The writer has seen an arrangement in a manufacturing concern whose specialty is the making of mouse-traps that is

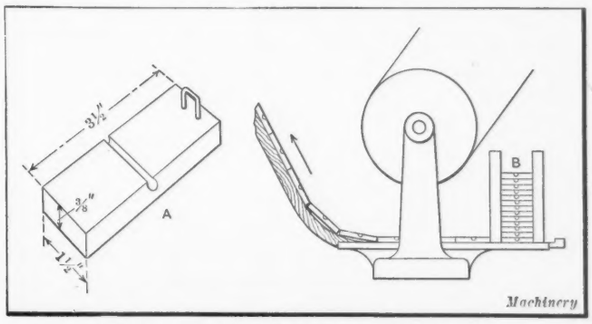


Fig. 1. Mouse-trap Block Hopper filled with Blocks

very interesting. The body of each trap is a piece of beechwood that comes to a staple machine as shown at *A*, Fig. 1. Because of market conditions, the blocks are often held up after this operation, and it was formerly the practice to let them fall out in back of the machine into boxes on trucks, in which they were stored until desired. The building in which the work is done has a roof supported on deep trusses, and it was decided to store the blocks in that space in hopper-bottomed bins with chutes leading down to the place where they would be used next, as illustrated in Fig. 2. The machine is tended by a girl who keeps the hopper filled with blocks *B*.

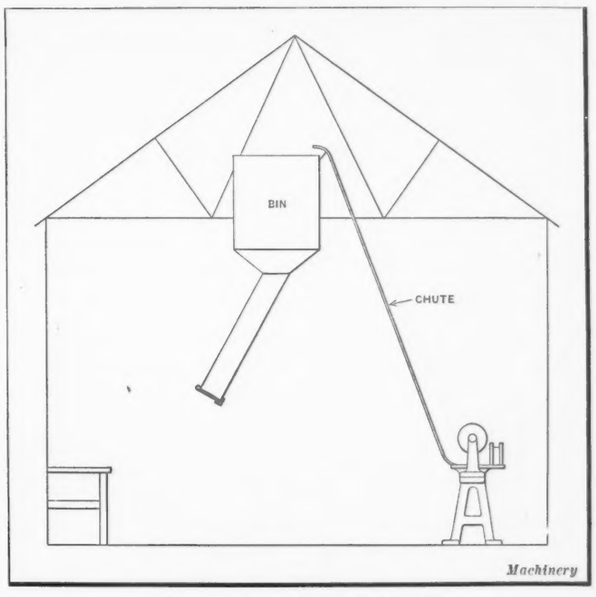


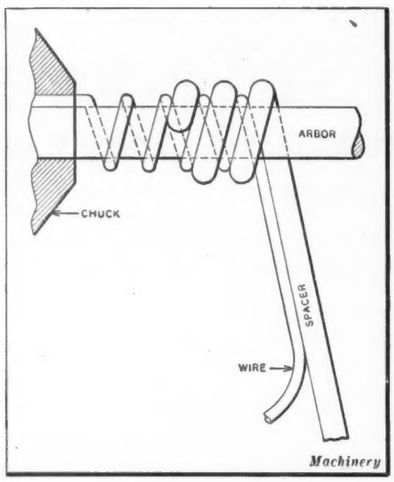
Fig. 2. Diagram of Mouse-trap Conveyor

A pusher shoves the bottom block out at the rate of forty a minute, and it is pushed up the incline into the bins. The blocks are light, and the pusher moves the entire load successfully. The runway is made of wood and takes up less floor space than the boxes formerly did. The curved portion was steamed to shape.

Middletown, N. Y. DONALD A. HAMPSON

SIMPLE SPRING-WINDING METHOD

In the July number of MACHINERY, there is described an easy method of winding a spring; but the method shown in the accompanying illustration is quicker and simpler and is available for any size and pitch. For instance, suppose that a spring of No. 16 wire and a ¼-inch space is to be made. First, a piece of ¼-inch cold-rolled steel, or whatever may be on hand, is wound around a piece of the same diameter as the arbor so that it will have a left-hand lead (that is, if an ordinary lathe is used) of about two and one-half coils with a space between the coils about 0.003 inch wider than the diameter of the wire used for the spring. Then the arbor is placed in the chuck, the spacer is slipped on over the arbor near the chuck, and the wire is fastened in the chuck. After the arbor is given a half turn, so that the spacer can be easily engaged with the wire, the machine is started and let run until the desired length is wound. Springs from ⅛ to 1 inch in diameter have been wound in this way with good results.



Quick Spring-winding Method

Newark, N. J. GEORGE WERNER, JR.

USING THE SHOP CLOCK IN PLACE OF THE PYROMETER

The other day it was necessary to harden a high-speed cutter when the pyrometer was out of order. But, fortunately, we had put a mark on the gas valve and had found that it required 1½ hour to raise the temperature of the furnace to 1700 degrees F. and that the temperature was then raised about 100 degrees each hour. So the furnace was started at one o'clock and at half-past two the cutter, packed in compound, was placed in it. At half-past three, the temperature of the furnace was 1800 degrees; at half-past four, 1900 degrees; and at half-past five, 2000 degrees. The cutter was then taken out and plunged in oil. After it was cold, the temper was drawn down to 500 degrees. The cutter was then given a severe test, cutting heavy steel gears. As it was 10 inches in diameter by 2 inches thick, its cost, including stock and labor, was nearly $100.

Worcester, Mass. E. M. PETERSON

SHRAPNEL-SHELL HOLDER

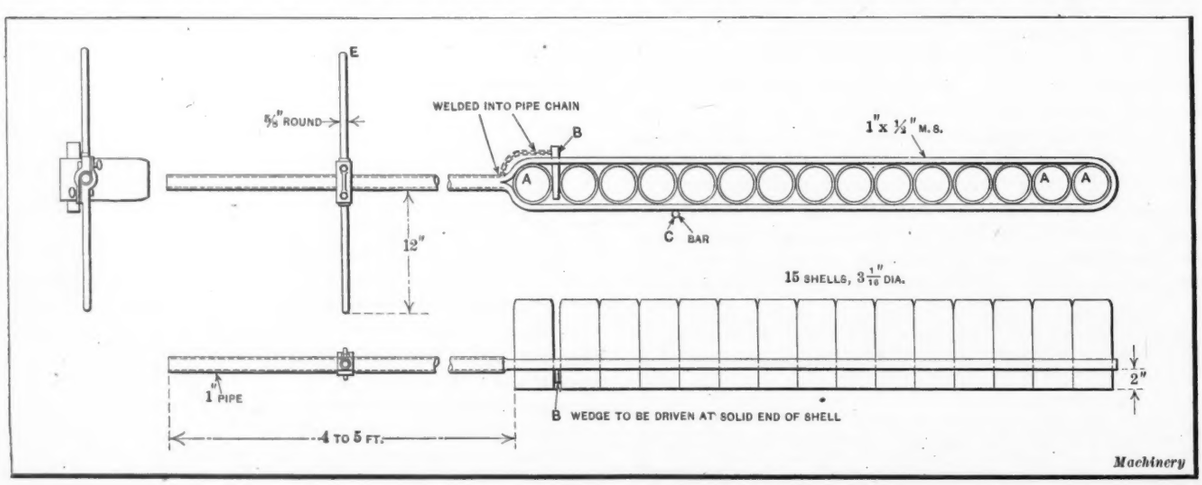
The shell-holder here shown was designed and used by the writer with excellent results in one of the prominent munitions factories. The method commonly used when heat-treating shrapnel cases is to place the shells in the furnace one at a time; in this factory, as forty-five shells were heated at one time, it took about eight minutes to load the furnace. As the furnace doors were open during this period, the pyrometer dropped about 300 degrees, and the operator absorbed most of the heat.

The holder shown can be built by a smith in two hours and will more than pay for itself in one day. The writer used three holders, which were kept on a bench about two feet high, three feet long, and two feet wide, placed conveniently near the furnace opening. While one load of shells is being heated, the cold shells (fifteen in each holder) are placed in the openings *A* and secured in place by a wedge *B*. When the furnace is ready, helpers place a porter bar *C* under the holder and the operator holds the handles *E*. After the shells are lifted to the edge of the furnace and pushed in by the operator, he turns them into the upright position, when the wedge drops from between them. The helpers again place the porter bar under the holder and, lifting it clear of the shells, pull it out of the furnace. Using this holder, the furnace can be charged in less than one and a half minute. When loading the furnace one at a time forty-five shells were heat-treated in thirty-five minutes; when the holder was used, the same number of shells were heat-treated in twenty-five minutes. This was an increase of over 25 per cent in production; besides, a considerable amount of fuel was saved.

Charlestown, N. H. JOHN FITZGERALD, JR.

HANDLING LARGE MACHINES

During the last three years, a great number of machines have been sent from the United States to Europe. These have been shipped in cases that generally bore on their tops the legend "This side up," and the condition of the machine on reaching its destination has depended on the care with which it was packed. But it is generally after the cases have been removed that the trouble begins. The machines are usually required in some other part of the factory, maybe up one or two stories, so the question arises as to where to take hold of it. If a crane is to be used for lifting the machine onto the truck, it must be decided where the ropes or slings are to be placed. If they are put in one place, the machine will not balance; if placed in another, a bar is bent or a bracket is twisted. Without doubt, the makers have been blamed for poor packing when the machine erector was to blame or the maker was to blame for not sending with the machine a blueprint giving the information. Motors and dynamos are nearly always provided with a hook or an eye to sling them with, but lathes, milling machines, etc., never have any provision for handling. Therefore the writer would suggest that the



Device for loading Shrapnel Shells into Heat-treating Ovens

makers enclose with each machine a blueprint that will show how the machine can best be handled so that slings will not injure it. If necessary, some holes should be left in the casting, so that one or more bars may be passed through when the machine is moved.

York, England JOHN SCOTT

PROBLEM IN TRIGONOMETRY

Some readers may be interested in a problem in trigonometry which occurred in our shops some time ago. It was desired to drive three pinions by one gear, and the accompanying illustration shows the dimensions given, and the dimension X required. We made the following trigonometrical computations to solve the problem:

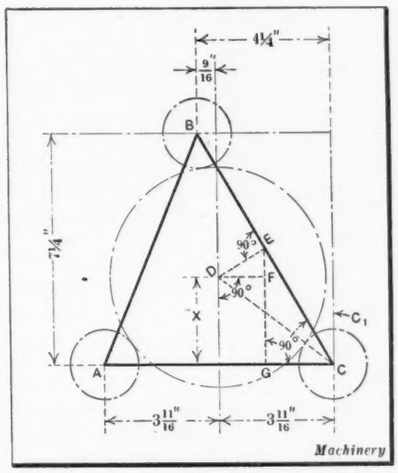


Diagram illustrating Solution of Problem in Trigonometry

$$BC = \sqrt{4.25^2 + 7.25^2} = 8.4038 \text{ inches}$$

$$\text{Tan}^{-1} C_1 = \frac{4.25}{7.25} = 0.586 = 30 \text{ degrees, } 22 \text{ minutes, } 46 \text{ seconds}$$

ACB = 90 degrees — 30 degrees, 22 minutes, 46 seconds = 59 degrees, 37 minutes, 14 seconds. CEG = 30 degrees, 22 minutes, 46 seconds

$$EC = \frac{BC}{2} = 4.202 \text{ inches}$$

EG = 4.202 cos 30 degrees, 22 minutes, 46 seconds = 3.626 inches

GC = 4.202 sin 30 degrees, 22 minutes, 46 seconds = 2.125 inches

$$DF = 3.688 - 2.125 = 1.563 \text{ inch}$$

EF = 1.563 tan 30 degrees, 22 minutes, 46 seconds = 0.916 inch

$$X = EG - EF = 3.626 - 0.916 = 2.710 \text{ inches}$$

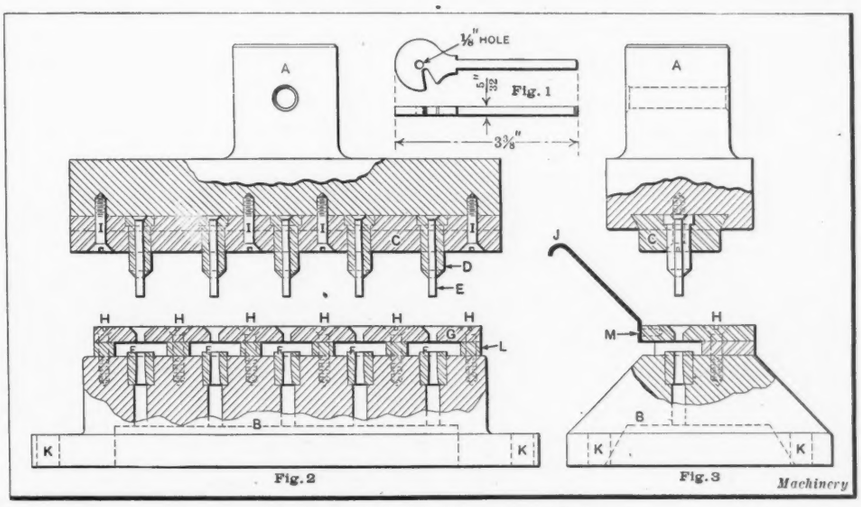
To find the center distance of gear to pinion solve for DC.

$$DC = \sqrt{2.710^2 + 3.688^2} = 4.576 \text{ inches}$$

C. O. H.

ECONOMICAL PERFORATING DIE

In Fig. 1 is shown a small stamping that must be produced in large quantities each day, but as the shape permits this part to be made from the waste from other jobs, it has been found more economical to make the part in two operations. As the thickness of the metal exceeds the punch diameter, a great strain is placed on the perforating punch, which, coupled with occasional breakage and the necessity of punching a clean hole, made it necessary to replace or grind the punch a number of times a day, thereby holding up production, as well as increasing the cost of grinding and replacing the punch. In order to keep the press operating more steadily, getting more production and a better quality of work, and reducing the cost of repairs to a minimum, a punch and die with five perforating punches and centering gages has been designed. This arrangement is superior to the single die, because the operator is able to shift from one punch to another if the punch he is using should give any trouble at all. The punch and die have been simplified in order that the necessary repairs may be easily and quickly made.



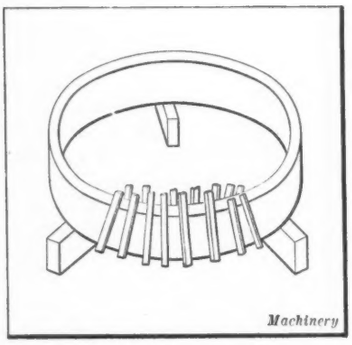
Figs. 1 to 3. An Economical Perforating Die

Fig. 2 shows the front and Fig. 3 the end elevation. The punch A is made of cast iron and has a hole through the shank, in which a pin is inserted to prevent the die from being drawn out or otherwise shifted while in operation. The steel plate C is hardened and ground and held in a dovetailed slot by flat-head screws I. Plate C, in turn, seats the hardened and ground tool-steel bushings D that hold the perforating punches E. The punches E are made from standard drill rod and their heads are upset. They are hardened and drawn to a light straw. The die B is made of cast iron and the bushings F are made from tool steel and are hardened and drawn to a light straw. Bushings F must have plenty of clearance so that the slugs will discharge freely; otherwise too great a tension may be put on the already overburdened perforating punch by reason of too many slugs being in bushing F at one time. The stripper G is held in position by flat-head screws H; it is made of machinery steel and is carburized. The tool-steel gage L is hardened and ground and is held in position by the stripper G and screws H. A guard J, Fig. 3, prevents the operator from getting his fingers caught between the punch and the stripper. This guard is made of ordinary sheet steel and is attached to the stripper G by small flat-head screws M. Holes K are provided for fastening the die to the bolster plate.

Highland Park, Mich. ERNEST A. WALTERS

SHRINKING ON BANDS WITHOUT TOOLS

A power plant had three tandem compound engines of a well-known make, all of 500 horsepower rating and less than ten years old. One day the crank disk of one of the engines burst, fortunately injuring no one, which led to an examination of the other two disks. One of these had two cracks extending radially from the hole, but the builders decided that it would be perfectly safe if a band were shrunk around the outside. This was accordingly done by men sent from the factory, and in the five years since the cracks have not opened up. Not long ago, however, it was found that the disk on the third engine was cracked, so the power-plant people asked a local machinist to shrink on a band. There are many machinists who have never done a shrinking job, and while they have a general idea of the process, they think it has to be done with gas and much special equipment and is beyond an untrained man if it has to be done in the field. This particular band, however, was shrunk on by the lathe hand who bored it out, the first job of the kind he had done; but working under instructions he and his helper went to the power plant four miles away, shrunk on the band, and returned to the shop in three and a half hours, using no tools whatever but two large monkey wrenches



Method of heating Band

to carry the hot band. The finished size of the ring was 1½ inch thick and 4 inches wide; the hole was made 0.04 inch smaller than the disk, which was 36 inches in diameter. The linear expansion of a piece equal to the circumference of the ring would be 0.848 inch if heated to a dull red, which gives a clearance of 0.23 inch over the diameter of the disk. It will be noted that this makes ample allowance for loss of heat in handling and also allows for a lower heat if a red was not fully reached.

Heating the ring, or band, was the simplest thing in the world. It was supported on three large firebricks out in the yard and a wood fire built all around it, as shown in the accompanying illustration. There was plenty of pine waste to be had and the helper piled it on. A rod the size of the expanded diameter served as a gage, and when it entered, the fire was immediately pulled, the ring turned up on edge, and carried to the engine room. The monkey-wrenches, with long pipe handles, make a pair of convenient handles for carrying and for placing the ring over the disk.

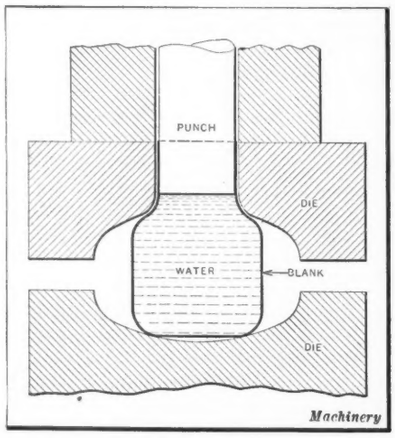
There always seems to be a little uncertainty as to how much larger the ring will be when heated than the piece it goes on. For work of this kind, the increase in internal diameter is roughly 0.002 times the mean length of the ring, assuming that it is heated to a red—but it must be remembered that a red appears in a dark room sooner than in sunlight.

DONALD A. HAMPSON

Middletown, N. Y.

MAKING A ONE-PIECE BRASS DOOR KNOB

In the article in the June number of MACHINERY describing the process of making one-piece brass door knobs, one important step was omitted. When the blank *F*, Fig. 1, is to be drawn to the form shown at *G*, it is placed in a die that is split horizontally, as shown in the accompanying illustration, which shortens and bulges it so that it will enter the die shown in Fig. 2 of that article.



Split Die used in making Brass Door Knob

ROBERT MORRIS

A POINT IN DRILLING MACHINE DESIGN

On sensitive drilling machines, binding of the sliding head and lower sliding member is accomplished by simply tightening two levers, but I wonder how many of MACHINERY's readers have noticed on which side of the machine these levers are placed. On most sensitive drilling machines, both binding levers are located at the left-hand side. It will be noticed that the lower binding lever on the sensitive drilling machine is not located in the same position as the table binding lever on the average upright drilling machine. On the latter it will almost invariably be found that the binding lever for the sliding head is located at the left-hand side, just as it is on the sensitive drilling machines; but the clamping lever for the circular table and the crank for raising and lowering this table are located on the right-hand side, *i. e.*, in the position directly opposite that in which these levers are placed on most sensitive drilling machines.

If the larger drilling machine is more conveniently manipulated with the table binding lever and elevating crank located at the right-hand side, why is this not true of sensitive drilling machines? As the lower support will go on the machine just as well with the binding lever to the left or right, I have reversed it on its slide and have noticed that the sensitive drilling machine altered in this way is much more convenient to operate. In centering lengths of steel, one end of the bar is set in the cup center, and the natural position is to hold the bar with the left hand and adjust the center with the right hand. Of course, one must get used to the fact that with the binding lever of a sensitive drilling machine table reversed in this way, tightening is done by turning the lever in the opposite direction to that used in tightening an upright drilling machine, because both levers turn screws with right-hand threads. I was interested to see if sensitive drilling machines are really assembled with the levers at the left-hand side, as I have mentioned. Upon referring to the advertising pages of MACHINERY and to manufacturer's catalogues, I found that in nearly every case both binding levers are located at the left-hand side, while on upright drilling machines the table binding lever and elevating crank are at the right-hand side. What is the reason for this difference of design of two machines that are operated in essentially the same way?

Worcester, Mass. CLARENCE ANDERSON

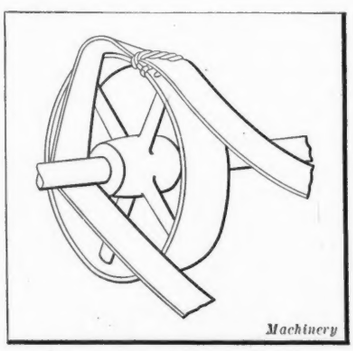
It is scarcely safe to say that the principles of drilling machine design to which reference has been made are followed in the construction of all sensitive and vertical machines. On sensitive drilling machines, the binding levers for both the head and table are generally placed on the left-hand side, because both the head and table are adjusted by hand and it is more convenient to use the right hand for this purpose and to tighten the binding lever with the left hand. A further reason for placing the head binding lever on the left-hand side is that in some cases it would interfere with the feed-lever if placed at the right-hand side of the machine. On vertical drilling machines where a screw and crank are provided to adjust the position of the table, the natural method is to locate this crank on the right-hand side of the machine because most men are right-handed. Where such means are used for adjusting the table, the position of the binding lever is a matter of little importance. On all machines where an elevating screw is not provided, it is probably better practice to locate the binding lever at the left-hand side.—EDITOR

PLACING TIGHT BELTS ON PULLEYS

Considerable difficulty is often encountered in putting tight belts over pulleys; and since the pulleys are usually located at some height, the proposition is troublesome and dangerous as well, even though hooks and other devices are available for the purpose. The writer recently saw a belt put over a pulley by means of a piece of rope, which seems a simple and effective method, free from danger. The belt is first pulled up to the pulling side of the driving pulley and a rope is wound around the pulley rim and over the belt where it comes in contact with the pulley face. The ends of the short piece of rope are then placed underneath the belt, that is, between the belt and the pulley face, as shown in the accompanying illustration. When the power is turned on, the ends of the rope are clamped between the pulley face and belt so the rope is held tight and pulls the belt around with it on the pulley face. After making a half revolution, the grip of the pulley on the rope relaxes, so the rope releases the belt and falls away, leaving the belt on the pulley. If just enough rope is used to encircle the belt and catch itself between the belt and pulley, there will be no trouble, as the rope does not release itself.

W. A. LAILER

Philadelphia, Pa.



Using Rope for placing Tight Belt on Pulley

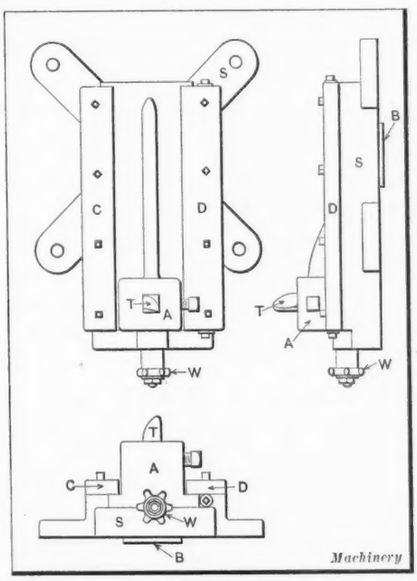
FINDING FACE AND CUTTING ANGLES FOR STUB-TOOTH BEVEL GEARS

In MACHINERY'S HANDBOOK, tables are given for face and cutting angles for the ordinary bevel gear, but for a stub-tooth gear it is necessary to calculate the addendum angle, and subtract it from the pitch cone angle of its mating gear, to find the face angle. In our drawing-room we have discovered that the difference between the addendum angle of a regular tooth gear and a stub-tooth gear is proportional to the diametral pitch; that is to say, in gears having the same number of teeth, the addendum angle of a 10/12 pitch gear would be 10/12 the addendum angle of a 12 pitch gear. To use the tables in MACHINERY'S HANDBOOK, find the difference between the face angle and the pitch cone angle of its mating gear, and make this in proportion to the pitch. This is not theoretically correct, but as it is inaccurate only 0.6 minute, in what is apparently the most severe test, it should be sufficiently accurate for all practical purposes. C. O. H.

FIXTURE FOR FACING WORK CARRIED ON A LATHE CARRIAGE

The fixture shown in the accompanying illustration was designed to face the ends of some heavy castings of square section that were too large and too heavy to swing on centers in the largest lathe available for the job. The fixture made a satisfactory record in removing the stock—from ½ inch to 2 inches—from the various castings, and is used quite frequently on other jobs.

The spider *S* is bolted to the lathe faceplate, the boss *B* fitting into the hole in the center. A slide *A* carries the cutting tool *T*, which is fastened by the set-screw shown. The wear of the slide is taken up by a gib by means of a collar-head screw at each end and is held to the spider by the plates *C* and *D*. A nut that engages with the feed-screw is attached to the under side of the slide by two cap-screws. This feed-screw, in turn, is operated by the star-wheel *W*, which is actuated automatically by a tripping finger clamped to the bed of the lathe. The screw may be turned by hand, when it is necessary to move the slide for some distance, by means of a small crank that fits over the star-wheel. The castings are firmly clamped to a cast-iron saddle bolted to each end of the carriage ways. A cut 3/8 inch deep, with a feed of one tooth of the star-wheel, or 1/36 inch, is used.

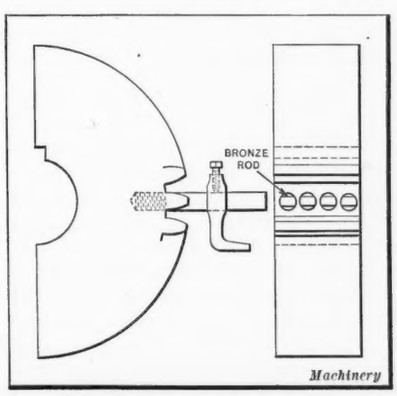


Fixture for facing Work carried on a Lathe Carriage

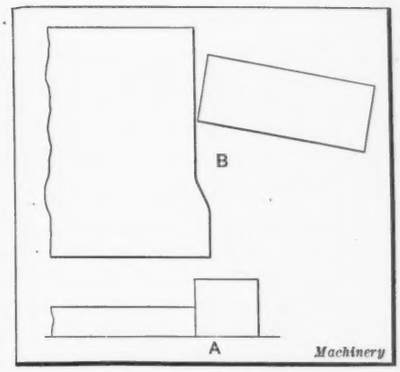
Watervliet, N. Y. MARTIN H. BALL

REPAIRING RAWHIDE PINION

One day, when the cupola was shut down, it was found that several of the teeth of a rawhide pinion on the blower were giving way. This pinion was 12 inches in diameter, 1¼-inch circular pitch, and had a 3¾-inch face. As it was necessary to run the heat the next day, it was decided to effect a temporary repair until a pinion could be shipped from the makers. So the worn teeth of the rawhide were chipped off and filed smooth; then the spaces were laid out for four plugs, as shown in the accompanying illustration, and holes made with a ratchet drill for a ¾-inch tap. Bronze plugs 13/16 inch in diameter and about 4 inches long, threaded on one end, were screwed tightly into place by a carrier attached to the bronze rod, as shown, and were then cut to the proper length. A templet showing the shape of the teeth was made and the teeth were rasped down and finish-filed to the templet. Bronze was used because it could be quickly worked into shape. The rawhide pinion repaired in the manner described was entirely satisfactory and it held out for the two weeks that elapsed before the new pinion was received from the factory. C. H. M.



Repairing Teeth in a Rawhide Pinion



Handy Surface-plate Block

HANDY SURFACE-PLATE BLOCK

The plain block shown above is made of tool steel, hardened and ground as square as possible. When working the surfaces of small parts to form by hand, particularly when working a form gage, this block aids in making the surfaces square with the face. Resting upon the surface plate with the work, and with one of the sides coated with Prussian blue, the block, if applied as at *A*, will mark the points of the gage that must be removed in order to bring the side square with the face. If the amount to be removed is very small, the gage may be scraped with the corner of the block as at *B*.

Newark, N. J. GUSTAVE A. REMACLE

WASHING CONCRETE AGGREGATES

The statement on page 1108 of the August number of MACHINERY, that washing the aggregate increases the strength of hand-mixed concrete 30 to 40 per cent, and of machine-mixed concrete, 15 to 20 per cent, is misleading, because often it is quite the reverse. The result of washing depends on the cement, as the various kinds are differently susceptible to dirt. Some kinds of dirt are exactly what some kinds of cement need to attain their full strength.

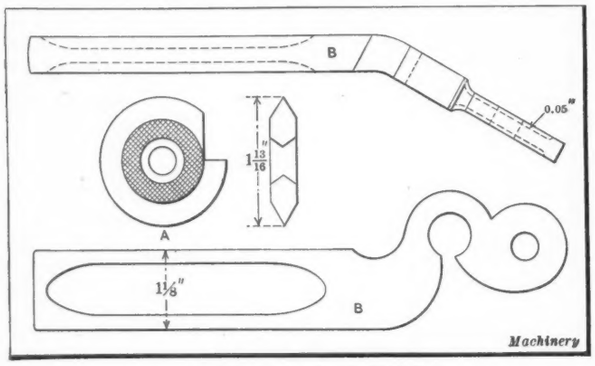
The writer had considerable experience in Germany with this material, as the Bavarian State works, for which he acted as consultant, made eighty tons a day of slag cement (not a Portland cement mixed with slag, but one made from blast-furnace slag), which acted very different from most of the cements on the market. Passow, the greatest German authority on cement, says: "There are cements which mixed with clayey sand show much higher strength than when mixed with normal sand; while others, similarly tested, are markedly reduced in strength. In all cases where sand with considerable dirt is to be used, it is essential that the sand be thoroughly tested with the cement to be used, in order to establish the influence of the impurities. This rule is often neglected."

Another point, not generally known, is that while the setting of real Portland cement is retarded by the admixture of a small proportion of so-called plaster-of-paris, the same addition hastens the setting of the slag cement above mentioned, which is called in Germany "montanzement."

New York City ROBERT GRIMSHAW

SPRING THREADING TOOL

A tool that has proved useful when cutting V-threads on tool-steel screws is shown at *A* in the accompanying illustration. The holder *B* is made from ½ inch by ⅛ inch spring steel, which was 6 inches long before bending. The gooseneck shape allows it to spring and eliminates chattering to a large extent during a finishing cut. However, when a roughing cut is being taken and a stiffer tool is required to prevent digging into the work, a ground disk is slipped into the recess, making the tool quite solid. The cutting tool is a circular disk of high-speed steel fastened by a bolt to the holder, which fits in the toolpost of the lathe. The hole through the center of the cutter is ⅜ inch in diameter and is recessed at an angle of about 80 degrees on each side; the cutter is checkered on both sides, which allows a firm grip on the face of the tool-holder and prevents slipping.



Useful Threading Tool and Tool-holder

The tool can be used on either side of the tool-holder, which enables a thread to be cut up to a shoulder, either on the right or left side of the work in the lathe. This tool can be taken off the holder, reground, and replaced without altering the position of the holder, which is a great help when cutting a good thread. Two bolts and nuts were made to secure the cutter to the holder, one having a left-hand thread for right-hand cutting, and the other having a right-hand thread for left-hand cutting. The heads of these bolts have an angle of 80 degrees on the under side, which coincides with the angle in the hole of the cutter, by which means a greater bearing surface is obtainable. As standardization is rapidly gaining ground in the mechanical field, we will sooner or later standardize lathe cutting tools, and a round-nose tool of this type may become adopted with considerable advantage for the turning of all parts in lathes that have less than a twelve-inch swing.

New Haven, Conn. ERIC LEE

MILLING AUTOMOBILE THROTTLE HAND-LEVER WORMS

Recently we had a lot of automobile throttle hand-lever worms to make; a glance at Fig. 1 will make apparent the difficulties experienced because of the size of the worm and the amount of metal to be removed. The worm has a double right-hand thread with a 41-degree, 40-minute helix angle, a 29-degree tooth angle, and a 1.5625-inch lead. The thread is 0.128 inch thick at the root.

The first step was to develop the cutter shown at *A*, Fig. 2. For this kind of work, the face of the cutter must be a curve, as shown, and not straight, as might be supposed. The curve of the cutter must correspond to the curve formed by cutting the cylinder, at the root diameter of the worm, at an angle of 41 degrees, 40 minutes. But owing to the width of the cutter, there was considerable trouble due to chatter, distortion and interference, with the resulting undercutting. So, after repeated trials, this cutter had to be abandoned. Two similar cutters, fastened side by side on the spindle, as shown at *B*, are now used to form the tooth by straddle-milling it. The curved-face cutter is then used to trim the space between the teeth, the angular sides of the cutter having been ground so that they will not touch the tooth already formed. This cutter now works without any trouble, as the straight cutters remove more than half the stock.

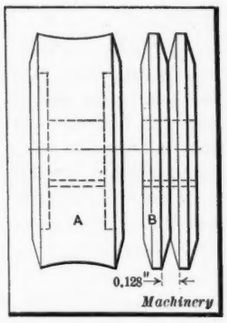


Fig. 2. Cutters used for milling Throttle Hand-lever Worm

As two operations were necessary to complete a worm, it was desirable to provide some means for cutting a number with the straddle cutters and then changing to the curved-face cutter and finishing, rather than changing cutters for every worm; therefore, a uniform setting and indexing in the thread miller was essential. Fortunately, there is a tapering square on the end of the worm, which solved the problem with the aid of the holder shown in Fig. 3. This holder fits over the live center of the machine, a square being filed in the bottom to receive the squared end of the worm. Also, a keyway cut to correspond with the key fitted in the live center allows the holder to slide but not turn. A spring pressing between the center and the bottom of the holder insures perfect contact between the squares. As shown in Fig. 1, a small hole is drilled in a fixed relation to the square in the worm, so the operator is instructed, when changing work, to see that this hole is in line with the set-screw in the holder, so as to cut all worms the same, also securing the same setting for the second operation.

Of course, it is necessary to put a small chamfer on the end of the worm while drilling the 5/16-inch hole, so as to use the tailstock center. As these worms are double threaded, an index plate with twenty-four holes is used. For the first operation, holes 1 and 13 are used; but after changing cutters, the plate is advanced a quarter turn, either from 1 to 7 or from 13 to 19, as the case may be.

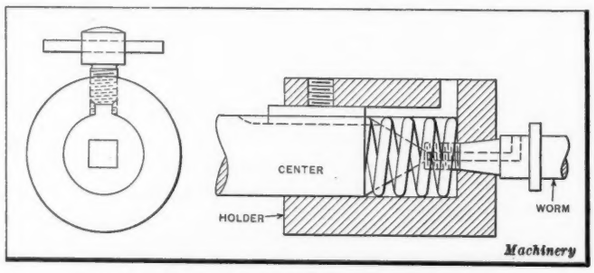


Fig. 3. Holder used in milling Throttle Hand-lever Worm

Springfield, Mass. P. J. VISCO

WHAT IS THE MATTER WITH THE DRAFTSMAN?

The draftsman is often found fault with. Some writers point out his weaknesses and give him advice, while others expose his faults. The demand is that the draftsman consider his work from the standpoint of the workingman and deliver a clear, complete "message" to the shop; one that will give no opportunity for confusion whatsoever. But where will the draftsman get his knowledge? He must often start the work without sufficient information, being favored instead by his supervisor saying, "If anything is not clear, ask about it," and because of this lack of information he fails to grasp the situation in general. The sketch he is furnished with in many cases is one that only a superman could comprehend. Often, after getting the necessary information by tireless hunting here and

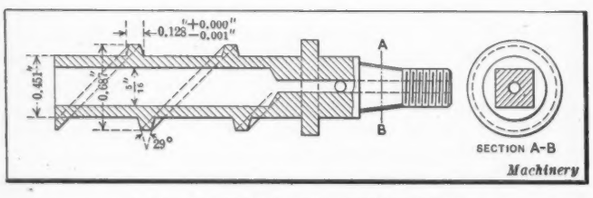


Fig. 1. Automobile Throttle Hand-lever Worm

there, many good draftsmen ask themselves, "How could the situation ever be clear, even to the best man in the world, by the facts presented at the start?" This state of affairs is the most favorable for the making of mistakes and confusion. Give the draftsman a square deal; don't make him guess the impossible.

Turtle Creek, Pa. B. A. WACH

KINK FOR CROSS-SECTIONING DRAWINGS

Uniformly spaced cross-section lines can easily be drawn if this suggestion is followed. As shown in Fig. 1, score two lines on the 45-degree triangle, making *B* 1/16 inch from edge *A* and *C* 1/8 inch; then fill in these scored lines with ink so as to make them heavier and clearer. To cross-section, place the triangle against the T-square and draw a line along the edge *A* of the triangle. Then move the triangle until line *B* or *C*, depending on the spacing desired, is over the line

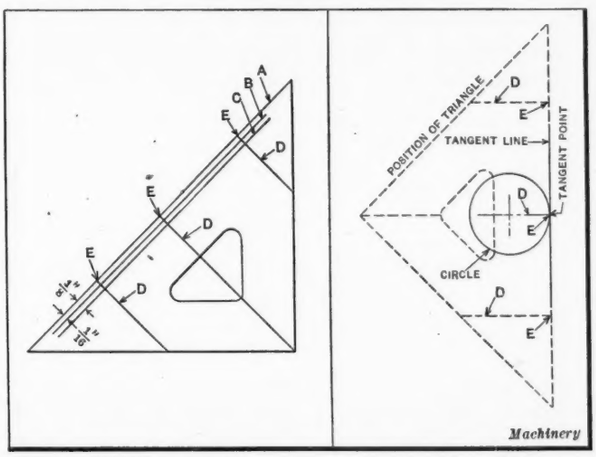


Fig. 1. Triangle marked for Cross-sectioning

Fig. 2. Using Triangle to draw Tangents

drawn, and draw a second line along edge *A*. Again place line *B* or *C* over the line drawn and draw the third line.

Tangents to curves and circles may be easily drawn, as shown in Fig. 2, if lines *D* are drawn at right angles to edge *A*. Place the tangent point *E* of any line *D* at the point in the curve or circle where the tangent is to be drawn, letting the line *D* pass through the center of the circle or curve; then draw the tangent along the edge of the triangle. The writer has used these lines on his triangles for the past three years and has found them exceedingly useful.

Pittsburg, Pa. M. J. STACK

MILLING CUTTERS WITH REMOVABLE HUBS

In Fig. 1 is shown an inserted-tooth milling cutter that differs from the ordinary cutters of this type only in that the

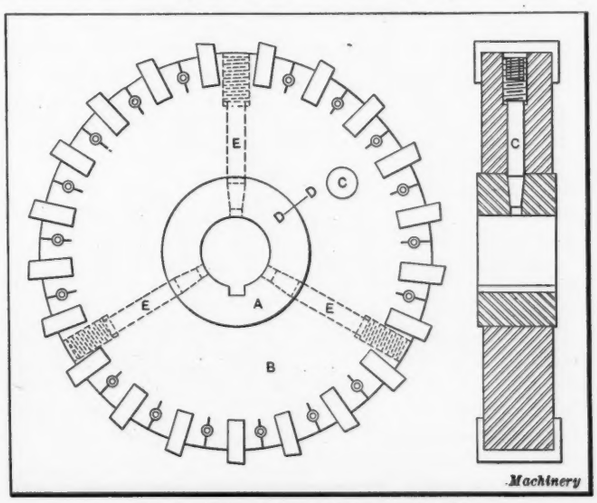


Fig. 1. Milling Cutter with Removable Hub

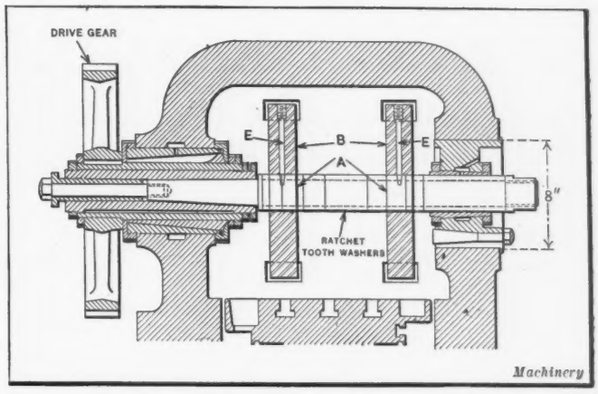


Fig. 2. Briggs Milling Machine, showing Cutter in Place

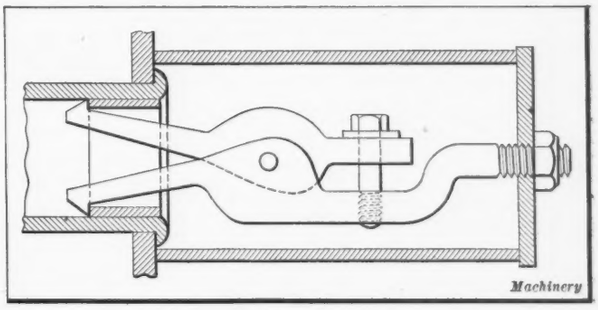
hubs *A* are removable. These cutters were designed to operate in a Briggs milling machine having a solid arch, through which the arbor and cutters are passed, as shown in Fig. 2. The capacity of the machine was limited to 8-inch cutters, but the work required cutters of 14 inches diameter. Split cutters were considered, but the removable-hub cutters were adopted; the latter were more easily removed, as the space necessary for side fastening was lacking.

The arbor was set up with the necessary spacing collars and the hubs *A* in place. The cutter disk *B* was suspended from the arch by means of a rod passed through the hole *C*, Fig. 1, and the assembled arbor was passed through the cutter disk and adjusted until the indicator marks *D* registered. Bolts *E* were then inserted and set down tight, the slightly tapering ends locating the hub centrally with the cutter body. The bolts *E* are solid throughout, threaded on one end, and countersunk to receive a hexagon wrench, as with set-screws. The work finished proved that these cutters were worth the investment. These cutters are run in pairs for straddle-milling.

Elmhurst, Ill. H. F. MCKNIGHT

BUSHING EXTRACTOR

The illustration shows a useful device for extracting ferrules from tube ends. It is adjustable for many sizes of tubes, and may also be used for extracting small bushings, valve



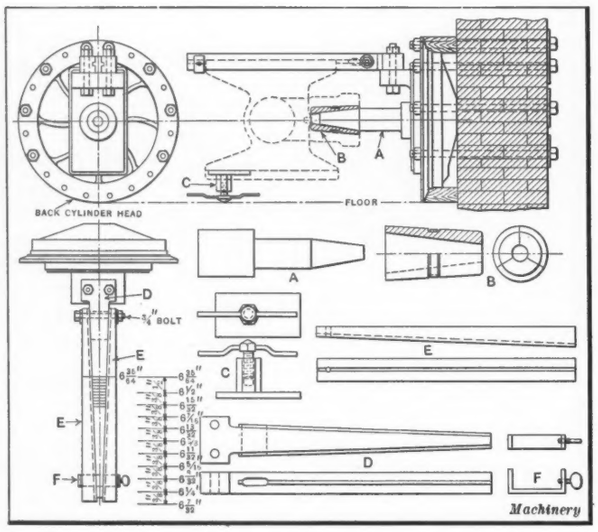
Bushing Extractor

seats, etc. It should be made from high-grade steel to give strength and long service. The illustration is self-explanatory, and needs no extra explanation.

Concord, N. H. C. H. WILLEY

BABBITTING SOLID CROSS-HEADS

For the benefit of fellow employes in railroad shops, I wish to describe a method of babbitting the guide bearings of solid cross-heads that has been the means of reducing labor and increasing the quality of workmanship. A back cylinder head is bolted to the wall of the shop and held away at the proper distance by means of wooden blocks. The large end of plug *A* is next put into the hole in the cylinder head, which is counterbored to receive packing and accessories. After this an adjustable bushing *B*, which is made in three parts and held together by a spring band, is put into the piston-rod end



Fixture for Use in babbitting Guide Bearings of Solid Cross-heads

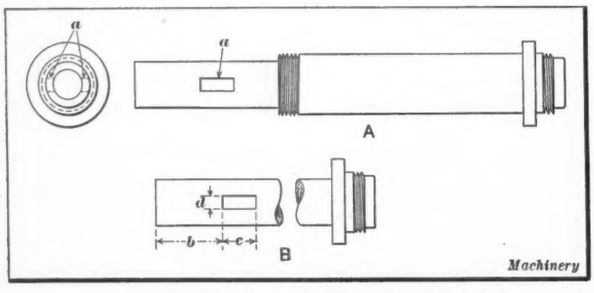
of the cross-head. The cross-head is then lifted so that bushing *B* can be slipped over the tapered end of plug *A*. A jack *C* provides for accurately adjusting the height of the cross-head so that it is supported in a perfectly level position.

After the work of setting up has proceeded to this point, pieces *D* and *E*, which are adjustable for width, are put in place and set to the proper width to suit the guides of the locomotive on which the cross-head is used. It will be seen that the side pieces *E* are held to center piece *D* by means of a ¾-inch bolt. This bolt passes through a slot in center piece *D*, so that side pieces *E* can move the bolt in order to make proper adjustment for the width of the guides on the locomotive. As indicated by the scale, this adjustment covers a range of from 6 7/32 to 6 35/64 inches. The pieces *D* and *E* are held in place at the outer end of the cross-head by means of clamp *F*. When the work has been set up in this way, babbitt is poured into the guide bearing, and after one bearing has been babbitted, it is a simple matter to turn the cross-head over and set the fixture up for babbitting the second bearing.

M. K.

WHO BLUNDERED—THE DRAFTSMAN OR THE MACHINIST?

Some time ago we had to redesign the spindles of a number of screw machines to adapt them for draw-in collets in



(A) Drawing of Spindle. (B) Sketch sent to Machinist

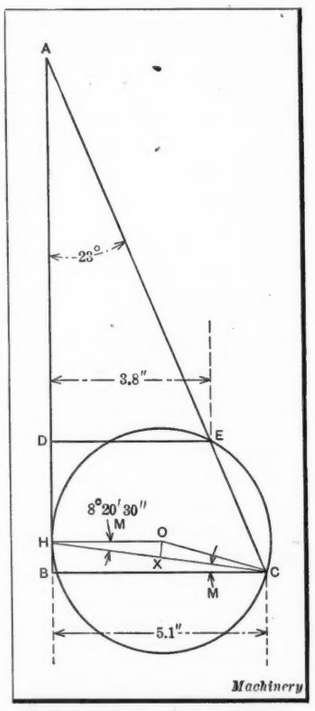
place of the push forward type with which these machines were provided. The only change required on the spindles was cutting two slots through one end for clearance through which the ends of the fingers that operated the draw-rod could project. These clearance holes *a* are plainly shown in the view at *A*, which also shows a complete view of the spindle. As no other machine work was required on the spindle, the drafting-room made a drawing like that shown at *B*, the only figures on it being those that show the actual dimensions of the slots and their location. The thread and the difference in diameter of the spindle were neither shown nor indicated by dimensions, as these were thought to be entirely unnecessary. The spindles, when taken from the machines, were sent out to a job shop to have the alterations made. Instead of going by dimensions only, they assumed, after having completed the work actually shown by the drawing, that we also wanted the spindles turned down to the size of the small end, and this they did, completely ruining ten spindles, as, of course, they turned off the thread and the bearing surfaces. Why they did not continue and break the spindles in two is a wonder. The whole job reminds me of the man who hired out in a railroad blacksmith shop and claimed to be able to read blueprints. When they gave him a drawing of a long connecting-rod which had been shown broken for convenience in getting it on a standard sheet, he inquired whether he was expected to make the teeth on the ends. Who should be held responsible in a case of this kind, the shop or the drafting-room?

New York City DONALD A. BAKER

FINDING RADIUS OF CIRCLE

The following is a simpler method of finding the radius of a circle than that given in the May number of MACHINERY:

$AE = \frac{DE}{\sin 23 \text{ deg.}} = \frac{3.8}{0.39073} = 9.7253$ and $AC = \frac{BC}{\sin 23 \text{ deg.}} = \frac{5.1}{0.39073} = 13.0522$. By geometry, $AC \times AE = (AH)^2$, so $AH = \sqrt{9.7253 \times 13.0522} = 11.267$. $AB = BC \times \cot 23$ degrees $= 5.1 \times 2.3558 = 12.0148$. $HB = AB - AH = 0.7478$. Tan $M = \frac{HB}{BC} = \frac{0.7478}{5.1} = 0.14644$; $M = 8$ degrees, 20 minutes, 30 seconds. $HC = \frac{BC}{\cos 8 \text{ deg., } 20 \text{ min., } 30 \text{ sec.}} = \frac{5.1}{0.98942} = 5.1546$. $HO = \frac{0.5HC}{\cos 8 \text{ deg., } 20 \text{ min., } 30 \text{ sec.}} = \frac{2.5773}{0.98942} = 2.6049$, which is the radius desired.

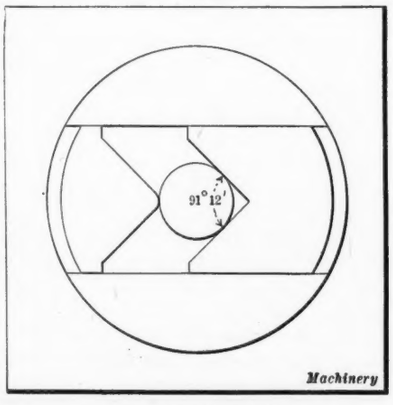


Method of finding Radius of Circle

Toronto, Canada OSCAR M. WOELFE

MOVEMENT OF V-REST

Referring to the V-rest problem answered by F. Webster Brady in the September number of MACHINERY, I would like to make a slight addition to the practical side of the problem. The illustration shows a device that I have used once or twice; I have found it of advantage to make one thread five per inch and the other seven per inch. In this case the included angle should be 91 degrees, 12 minutes, as any mathematical shark can readily show.



Jaws of Reid Drill Chuck

This is much easier than to monkey with fractional threads. So far as I know, this form of mechanism was first used in the Reid drill chuck, at least thirty-five years ago.

Eau Claire, Wis. C. M. CONRADSON

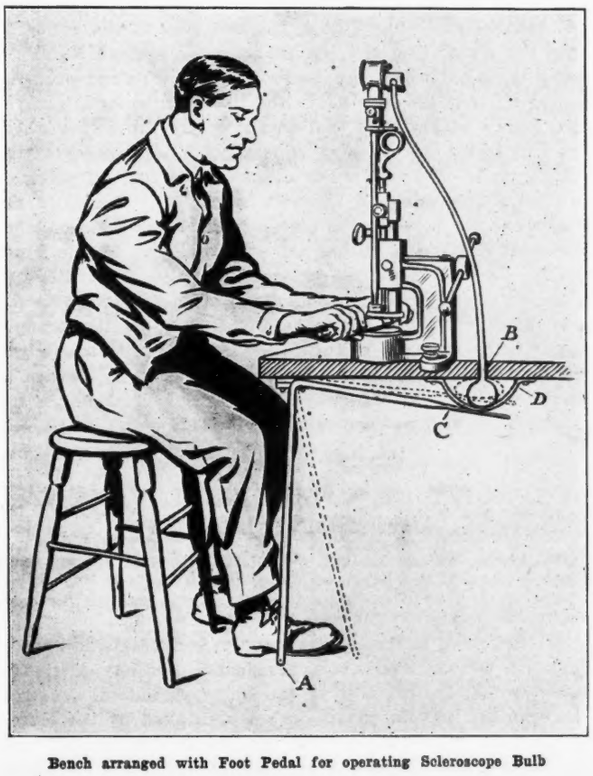
BALL BEARINGS FOR HAND-POWER DETAILS

Ball bearings, of both the journal and the thrust types, are an acknowledged success in the elimination of friction and consequent saving of fuel when applied to power-driven details. On that point all engineers are agreed. But why not carry their application a step farther and apply these bearings to journals of hand-power details? This matter is especially important now, when there is need for the greatest possible output, and every means should be used to keep the wheels of the factory turning. Could there be any better way to conserve energy than to apply ball bearings to all hand apparatus, such as winches, trucks, and other appliances used in transporting goods in a factory or outside erection? These bearings may even be applied to devices used to lift the shells for the big guns on the battlefield. At the present time, it is imperative that not an ounce of power, either manual or motive be wasted, and to provide the most efficient means of hand transporting of goods is certainly a matter demanding the closest attention.

Liverpool, England MARK MEREDITH

RAPID METHOD OF OPERATING SCLEROSCOPE BULB

The accompanying illustration shows a method of operating the bulb of a scleroscope which has been found to save a lot of time. This saving is chiefly due to the fact that operating the bulb with a foot-pedal *A* leaves both the inspector's hands free. It will be seen that a hole is drilled in the inspector's bench, through which passes a tube *B* connecting the bulb with the instrument. This bulb is held close to the under side of the bench and a piece of thin leather *D* is tacked over it to prevent the iron from wearing it out. A steel rod *C*, flattened at the end, is pivoted in such a way that when the pedal is pushed forward this rod will be swung up against the bottom of the bench and will compress the bulb. The inspector sits at the bench with his foot resting on the pedal as shown, and when he desires to operate the scleroscope the pedal is pushed forward.

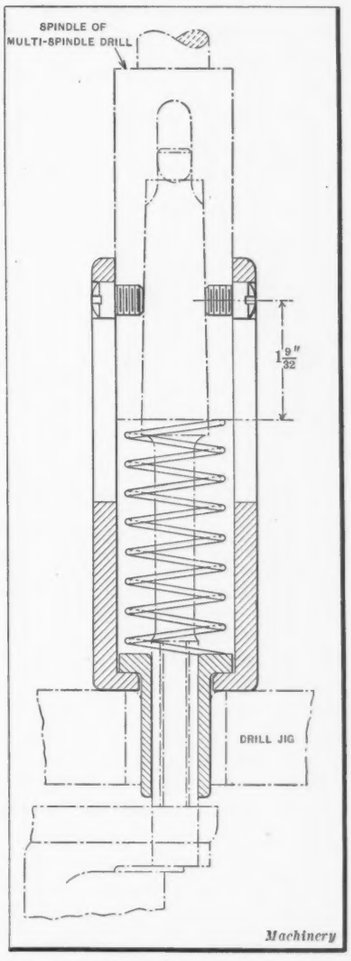


Bench arranged with Foot Pedal for operating Scleroscope Bulb

Flint, Mich. C. C. SPREEN

PUMP-SPRING BUSHING-HOLDER GUIDE

In the July number of MACHINERY appeared an article entitled "Multi-Machining in Production Quantities," which showed a stationary pilot for multi-drilling and reaming tools. The pump-spring bushing-holder guide here shown has the advantage of allowing the bushing to rotate with the drill or reamer when the bushing is not engaged with the permanent bushing in the drilling jig. This feature does away with wear of the drill in the bushing, which is a point to be considered, especially in reaming. This device has been used for the past nine months, and is working satisfactorily in every way. While it was designed for use on a Baush multiple-spindle drilling machine, it is also used in a horizontal position for cross-boring, as the position does not affect its operation. It was intended for use instead of the large, heavy, costly pump-spring bushing plate that was required when there were only a few holes but with large center distances. These devices cost $18.60 each.



Bushing-holder Guide with Pump Spring for Use with Drill Jig

EARL S. HUTTON
Detroit, Mich.

LAYING OUT INACCESSIBLE PARTS

Recently the writer had to repair a large cone pulley that had raised binder lugs, which had been torn off. A plate was substituted for the broken lugs and was fitted over the arms with a bearing on the sides. But it was found that it was impossible to lay out the arms on the plate, as the under side of the plate could not be reached. The following plan was finally hit upon: A torch was made by wrapping some oily cotton waste around a piece of wire, and, after lighting, it was passed into the cone through the opening around the edge of the plate. By holding the torch under each arm until it was well smoked the outline of the arm was left upon the plate, for there was no soot on those parts of the plate that were protected by the arms. When the plate was removed, it was easy to prick-punch the outline of the arms and mill the necessary slots. F. J. D.

CHEAP PARTITIONS

Paneled partitions can be made out of regular stock doors placed edge to edge, with strips top and bottom to give the line, more cheaply than by cutting lumber; and the doors have higher salable value when the partitions are no longer needed. Telephone booths may be made cheaply of these doors and a board top.

New York City ROBERT GRIMSHAW

HOW AND WHY

QUESTIONS ON PRACTICAL SUBJECTS OF GENERAL INTEREST

PRIZE FOR PERPETUAL MOTION

C. C. S.—Do you know of any prize offered for a working model of a perpetual motion apparatus?

A.—No official prize for a perpetual motion machine has ever been offered, so far as we know, and probably none ever will be offered. It is agreed by all who understand the principle of energy conservation that a perpetual motion machine is an impossibility.

CHANGE-GEARS FOR CUTTING WORM

C. G. M.—What should be the compound change-gears used in a milling machine for cutting a worm with a lead of 1.5781 inch?

A.—If the worm is to be cut on a standard milling machine, the ratio of the change-gears will be 1.5781 to 10. The selecting of these gears will be comparatively easy if the tables in an article, "Simplified Change-gear Calculations," published in MACHINERY, May, 1917, are used. By placing a 29-tooth gear on the worm-gear stud, meshing with a 73-tooth gear on the intermediate stud, and placing another 29-tooth gear on the same intermediate stud, which is also driven by a 73-tooth gear on the feed-screw, you will mill a worm with a lead of 1.5781 inch.

STRAIGHTENING THIN-WALL TUBING

H. E. G.—I wish to obtain some information on straightening thin-wall tubing. Our tubing is made of brass and comes in lengths of 10 feet. The wall thickness is 0.010 inch. Some of the tubing is cylindrical, having an outside diameter of 0.125 inch, and some of it is bean-shaped in cross-section.

A.—The cylindrical tubing may be straightened with a pair of rolls set with their axes out of parallel and with their peripheries apart a distance equal to the thickness of the tubing. The rolls are belted to run in the same direction. The tubing is fed between them from one end and is shot out of the other in a straightened condition. Ordinary wire straighteners of the revolving frame and roller type can be used successfully on tubing for taking out kinks if of not too short radius. The bean-shaped or elliptical cross-section tubing may be drawn through a die to straighten it. Readers who have had experience with this work are requested to contribute whatever they can on the subject.

DUTIES OF MASTER MECHANIC

G. A. V.—What constitutes the duties of a master mechanic? How does the position of master mechanic compare in rank with that of chief engineer?

A.—The duties of a master mechanic differ widely. In some places he is an important official, while in others his duties are minor. The master mechanic of a mill should be in charge of the repair and maintenance of machinery, the erection of all machines, motors, belts, pipes, electric wires, compressed air equipment, etc. The moving of machines from one department to another should be part of his duty, and the oiling of lineshafts, countershafts, and other bearings not in the immediate charge of any mechanic or workman. The chief engineer should be in charge of the design and layout of plant and machinery. He is not an executive officer in the larger sense, but one who plans work for others to execute. However, the chief engineer may also be an executive and in immediate charge of those who carry out his plans. Ordinarily the chief engineer ranks higher than a master mechanic, but they may be coordinate. The master mechanic may be in charge of the machinists, mechanics, electricians, and laborers required outside the machine shop for the care and maintenance of machinery and equipment in his charge, while the chief engineer may have charge of the drafting department and be the superior of the foremen of the machine shop, pattern-shop and foundry.

QUARTER-TWIST BELTS

B. C. S.—I should like a good rule for quarter-twist belts, one that can be used for any case when the shafts are not parallel.

A.—Referring to the illustration, *S* and *T* are two pulleys, the axes of which are represented by *AB* and *CD*, respectively. In the present case, the axes are at right angles to each other, thus giving a quarter twist to the belt, but the rule given will apply to any angle that the axes may make with each other. Let *PQRM* represent the middle plane of the pulley *T*, which intersects the pulley in the circle *PQN* (shown by the dotted line), and let *MPVW* represent the middle plane of the pulley *S*, which intersects the pulley in the circle *MWO* (shown by the dotted line). Now if *S* is the driving pulley, and it turns in the direction indicated by the arrow, the belt must be placed as shown in order to turn the other pulley *T* in the direction of the arrow *H*. The belt can come off the pulley at almost any angle without running off, but it must go on the pulley in such a manner that the center line of the belt will lie in the middle plane of the pulley receiving the belt. Note that the center line *PO* lies in the middle plane *MPVW*, *O* being the point where the center line of the belt goes on the pulley *S*; that the center line *MN* lies in the middle plane *PQRM*, *N* being the point where the center line of the belt goes on the pulley *T*; that the line *MP* is the line of intersection of the two middle planes; and that *M* and *P* are the points where the belt leaves the pulleys. *M* is a point of tangency of the middle plane of *T* with pulley *S*, and *P* is a point of tangency of the middle plane of *S* with pulley *T*. Hence, if the shafts are not parallel, the pulleys must be so arranged that the middle plane of either pulley is tangent to the other pulley. If it were desired to have the pulley *T* turn in the direction of the arrow *H'*, pulley *S* continuing to turn in the same direction, pulley *S* must be shifted on its shaft an amount equal to the diameter of the pulley *T*, and the belt arranged as indicated by the dotted lines. It is necessary always to remember that the center line of the belt must lie in the middle plane of the pulley on which the belt goes. J. J.

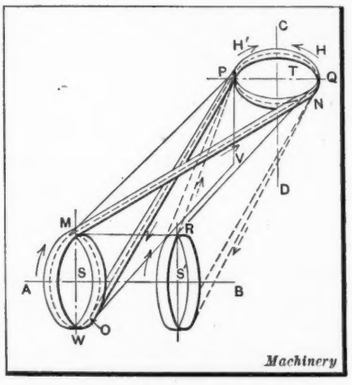


Illustration of Quarter-twist Belt

CAPACITY OF CYLINDRICAL TANK AT DIFFERENT LEVELS

W. A. F.—We have a cylindrical tank that is 90 inches in diameter and 18 feet long, so placed that its axis is horizontal. Please show how to calculate the contents in gallons for each six inches of depth. The ends of the tank are flat.

A.—Referring to the illustration, the horizontal lines represent the various levels, 6 inches apart. For any particular level, as *AB*, the contents in gallons is equal to the area of the segment *ACB* in square inches multiplied by the length of the tank in inches, and the product divided by 231. Let A = area of any segment; h = height of segment; r = radius;

and V = central angle. Then, $A = \frac{1}{2}r^2(V - \sin V)$. V is measured in radians, and is found as follows: For any level, as AB, $\cos \frac{V}{2} = \frac{r-h}{r} = \frac{45-6}{45}$. With the aid of a table of sines and cosines, find $\frac{V}{2}$; the result multiplied by 2 gives V. If a table giving angles in radians is not available, express V in degrees and decimal of a degree; then, $V = 0.0174533V$ in degrees. The area of the segment is then readily computed. By repeated applications of this process, the area of the segment that corresponds to each level is found. When the level FG is reached, the areas above it may be obtained by adding to the area last found the corresponding area below HI. Thus area $FGML$ = area $HIJK$, and area $HIJK$ = segment HCI — segment KCJ, both of which areas have been previously calculated. Since 18 feet = 216 inches, the capacity at any level is $C = \frac{216A}{231} = 0.935065A$. Using a five-place table of logarithms and natural trigonometric functions, the writer obtained the results given in the table.

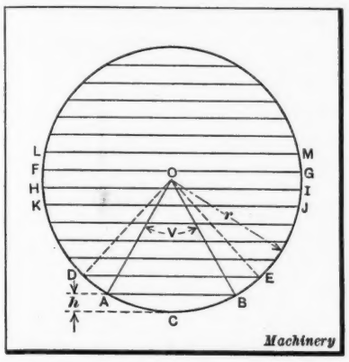


Diagram illustrating Method of finding Contents of Tank

Depth	Area of Segment	Gallons	Depth	Area of Segment	Gallons
6	182.1	170	54	3985.4	3727
12	504.3	472	60	4505.4	4213
18	905.8	847	66	4999.8	4675
24	1361.9	1273	72	5455.9	5102
30	1856.3	1736	78	5857.4	5477
36	2376.3	2222	84	6179.5	5778
42	2911.6	2723	90	6361.7	5948
48	3450.1	3226			

J. J.

STRESSES IN A CRANE

F. P. T.—I enclose a sketch of a crane. With the dimensions given, what will be the stress in the tie-rod BA and in the strut BC when the load is 5000 pounds? Also, what will be the bending moment at A?

A.—For practical purposes, sufficiently accurate results can be obtained by drawing the stress diagram to some convenient scale, and then determining the various stresses by measuring the lines of the diagram. Thus, draw A_1C_1 vertical and of such length as to represent 5000 pounds. If the scale is 1 inch = 1000 pounds, A_1C_1 will be 5 inches long. The line A_1C_1 then represents to scale the pressure at the foot of the mast DC due to the load of 5000 pounds. Then draw A_1B_1 parallel to AB, and C_1B_1 parallel to CB; they intersect at B_1. Measuring A_1B_1 and C_1B_1 to the same scale as A_1C_1, A_1B_1 = 4800 pounds, the stress in AB, and B_1C_1 = 6400 pounds, the stress in BC. To find the bending moment at A, it is necessary to find the horizontal stress at A. Hence, resolve the stress A_1B_1 into the horizontal component A_1H and the vertical component HB_1. Measuring A_1H, it is found to equal 4750 pounds. The reaction at D equals $4750 \times \frac{18.75}{22} = 4048$ pounds. Therefore, the bending moment at A is $4048 \times (22 - 18\frac{3}{4}) \times 12 = 157{,}872$ inch-pounds. If it is desired to calculate the stresses and the bending moment, consider the triangle $A_1B_1C_1$. The lengths of the sides will be proportional to the lengths of the sides in the triangle ABC; hence, suppose $A_1C_1 = 18\frac{3}{4}$, $A_1B_1 = 18$, and $B_1C_1 = 24$. The angles are then calculated, obtaining $A_1B_1C_1 = 50$ degrees, 35 minutes, 50 seconds; $B_1C_1A_1 = 47$ degrees, 53 minutes, 5 seconds; and $B_1A_1C_1 = 81$ degrees, 31 minutes, 5 seconds. Now, taking A_1C_1 as 5000, $A_1B_1 = \frac{\sin A_1C_1B_1}{\sin A_1B_1C_1} \times 5000 = 4800$ pounds; $B_1C_1 = \frac{\sin B_1A_1C_1}{\sin A_1B_1C_1} \times 5000 = 6400$ pounds. Angle HA_1B_1 = 90 degrees — 81 degrees, 31 minutes, 5 seconds = 8 degrees, 28 minutes, 55 seconds; and $A_1H = 4800 \times \cos 8$ degrees, 28 minutes, 55 seconds = 4747.6 pounds. The reaction at $D = 4747.6 \times \frac{18.75}{22} = 4046.2$ pounds, and the bending moment at $A = 4046.2 \times 3\frac{1}{4} \times 12 = 157{,}802$ inch-pounds. It will be noticed that the graphical method is sufficiently accurate for all practical purposes. Note that the horizontal pressure at C is $GC_1 = HA_1$, the two forces being equal, but in opposite directions, thus forming a couple that tends to overturn the crane. Here GC_1 is the horizontal component of the stress in the strut BC.

J. J.

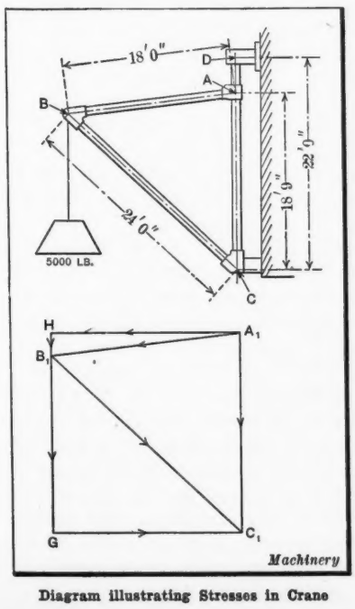


Diagram illustrating Stresses in Crane

PRESSURE ON BEARINGS DUE TO BELT PULL

F. H. L.—In the drive indicated by Fig. 1, the speed is 2000 revolutions per minute and the width of belt is 3 inches. Can you advise me what is the loading of the bearings due to belt pull, both for single- and double-ply belts? Also, what load per inch of width should be allowed for different thicknesses of belting?

Answered by John S. Myers, Philadelphia, Pa.

As neither the power it is desired to develop nor other conditions of service are stated, it will be assumed that this is a leather belt driving a machine readily accessible for retightening and under the care of a belt-fixer following scientific methods. Using a paper read by Carl G. Barth before the American Society of Mechanical Engineers, in January, 1909, as a basis, the curves of which are reproduced in Figs. 3 and 4, we have the following: (The lower-case letters represent pounds per square inch of belt section and the capital letters the total pulls in the given belt.)

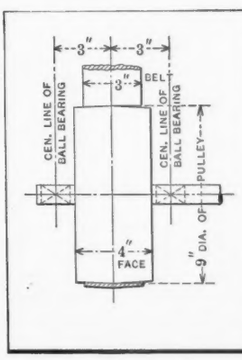


Fig. 1. Belt Drive

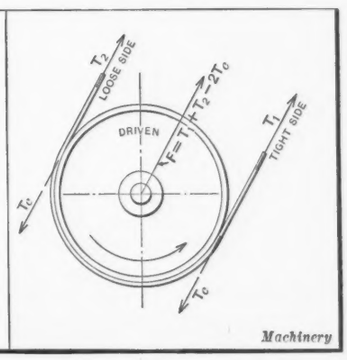


Fig. 2. Forces acting on Pulley

t_0 and T_0 = initial tension;
t_1 and T_1 = tension in tight side;
t_2 and T_2 = tension in slack side;
t_c and T_c = centrifugal tension;
p and P = effective pull for driving;
f and F = pull against bearings;
V = velocity of belt, in feet per minute.

Assume the arc of contact to be 180 degrees and take the coefficient of friction as a variable represented by the equation

$$\phi = 0.5A - \frac{140}{500 + V} \qquad (1)$$

For the conditions of service assumed, in order to avoid too frequent retightening or too rapid deterioration of the belt, the minimum initial tension t_0 of the belt is made such that when the belt is doing the maximum amount of work required of it

$$t_1 + \tfrac{1}{2}t_2 = 240 \text{ pounds per square inch} \qquad (2)$$

The pulley being 0.75 foot in diameter and the speed 2000 revolutions per minute, the belt velocity is:

$$V = 0.75 \times 3.1416 \times 2000 = 4712 \text{ feet per minute}$$

This is figuring on the net size of the pulley instead of to the center line of the belt to make some allowance for slip. The curves shown in Fig. 3 give, for this velocity, the approximate values: $t_0 = 142$, $t_1 = 190$, $t_2 = 100$, $t_c = 78$, $p = t_1 - t_2 = 90$. Then:

$$f = t_1 + t_2 - 2t_c \qquad (3)$$

Substituting the given values in this equation, $f = 190 + 100 - 2 \times 78 = 134$ pounds per square inch.

The cross-section of a single-ply belt 3/16 inch thick is $3/16 \times 3 = 0.5625$, say 0.56 square inch. The total pulls are then approximately: $T_0 = 142 \times 0.56 = 79.5$; $T_1 = 190 \times 0.56 = 106.4$; $T_2 = 100 \times 0.56 = 56.0$; $T_c = 78 \times 0.56 = 43.7$; $P = 90 \times 0.56 = 50.4$; $F = 134 \times 0.56 = 75$. The last value, $F = 75$ pounds, is the load acting upon the bearings, 37.5 pounds upon each, when the belt is developing its full capacity. The horsepower in this case is:

$$\text{H.P.} = \frac{PV}{33{,}000} = \frac{50.4 \times 4712}{33{,}000} = 7.2$$

When at rest, the tensions in both sides of the belt are equal; hence $T_1 = T_2 = T_0$, and, since $V = 0$ and $T_c = 0$, $F = 2T_0 = 2 \times 79.5 = 159$ pounds. For a double belt 3/8 inch thick, the various loads and power developed are twice those given for a single belt.

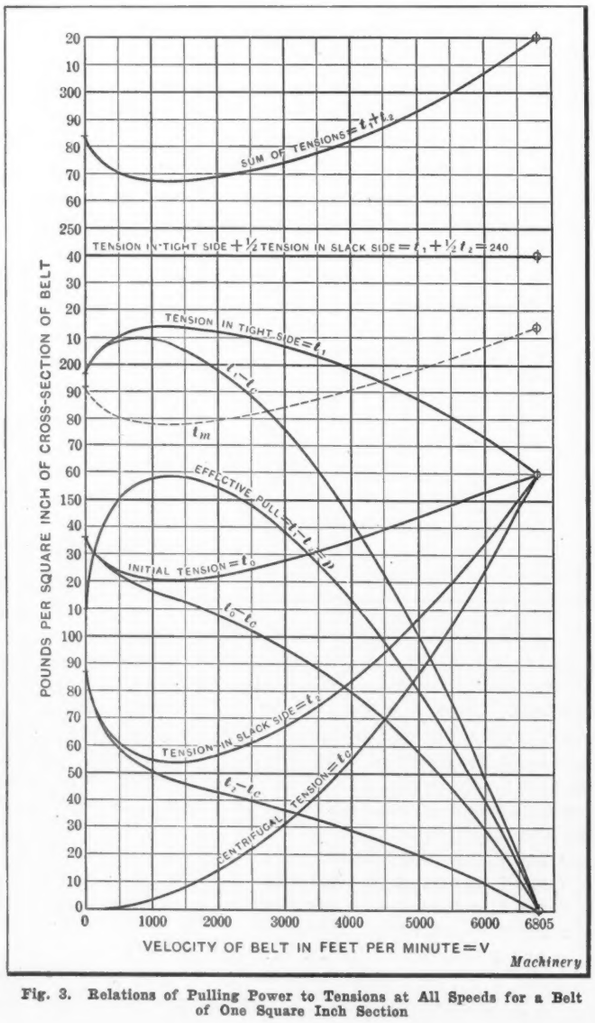

SUM OF TENSIONS = t_1+t_2
TENSION IN TIGHT SIDE + ½ TENSION IN SLACK SIDE = $t_1+\frac{1}{2}t_2=240$
TENSION IN TIGHT SIDE = t_1
t_1-t_c
t_m
EFFECTIVE PULL = $t_1-t_2=p$
INITIAL TENSION = t_0
t_0-t_c
TENSION IN SLACK SIDE = t_2
t_2-t_c
CENTRIFUGAL TENSION = t_c
POUNDS PER SQUARE INCH OF CROSS-SECTION OF BELT
VELOCITY OF BELT IN FEET PER MINUTE = V
Machinery

Fig. 3. Relations of Pulling Power to Tensions at All Speeds for a Belt of One Square Inch Section

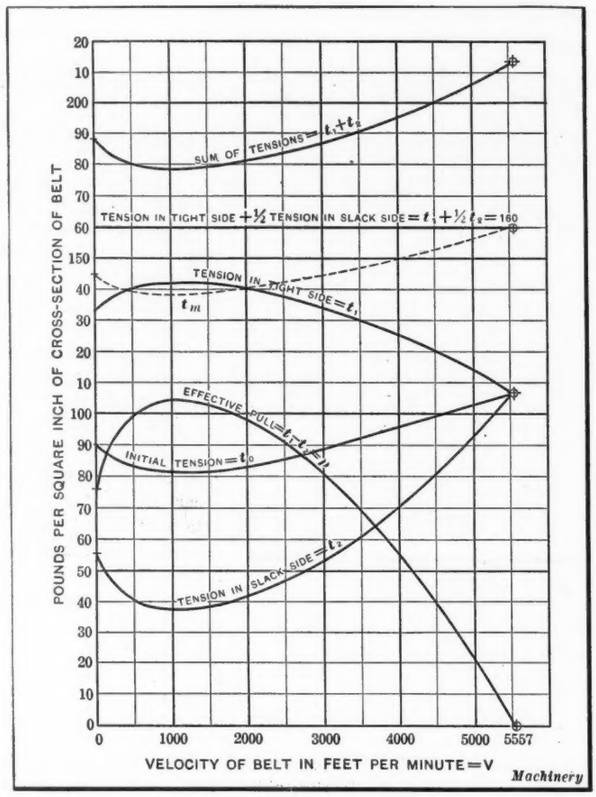

SUM OF TENSIONS = t_1+t_2
TENSION IN TIGHT SIDE + ½ TENSION IN SLACK SIDE = $t_1+\frac{1}{2}t_2=160$
TENSION IN TIGHT SIDE = t_1
t_m
EFFECTIVE PULL = $t_1-t_2=p$
INITIAL TENSION = t_0
TENSION IN SLACK SIDE = t_2
POUNDS PER SQUARE INCH OF CROSS-SECTION OF BELT
VELOCITY OF BELT IN FEET PER MINUTE = V
Machinery

Fig. 4. Relations of Pulling Power to Tensions when Pulley is on Countershaft

In the case of a countershaft belt, or a belt so located that it is not easily retightened, lower initial tensions are allowed, for which Mr. Barth adopted the values:

$$t_1 + \tfrac{1}{2}t_2 = 160 \qquad (4)$$

For such conditions, the curves shown in Fig. 4 are applicable.

* * *

STRAIGHTENING HARDENED TOOLS

One of the perplexing problems of manufacture that is practically unsolved, as regards the substitution of machinery for the human hand and eye, is the straightening of twist drills, sewing machine needles and smaller steel parts that are warped in hardening. The general practice in straightening twist drills is to provide the workmen with light hammers and surface plates, the latter being mounted on a level with the workman's eyes so that he can see daylight between the defective drill and the plate. He strikes the drill with the hammer at the point that experience determines to be the place where a blow is required, and rolls the drill on the plate to test it. Automatic machines for doing this work have been developed, but they were practically commercial failures on account of slowness, unreliability and the need of expert attendance.

Practically the same condition exists in the sewing machine needle industry, it being necessary to straighten defective needles by hand also. The operation of straightening needles is about as follows: A hard steel plate, about 8 inches square by 1¾ inch thick, is provided with a vee in the center about 7/16 inch wide. This plate is set in front of a window at an angle of 15 degrees, inclined toward the operator. The needles are rolled with the fingers on this plate and the operator is governed by the shadow that the needle throws upon the plate. If the needle is crooked, it will show by this shadow the amount of its eccentricity, magnified as the error is multiplied in the shadow, owing to the angle of the plate. The operator uses a small copper hammer to straighten the needle, placing the needle over the vee and striking a blow in the right place by a force that experience and judgment dictate.

NEW MACHINERY AND TOOLS

THE COMPLETE MONTHLY RECORD OF NEW AMERICAN METAL-WORKING MACHINERY

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CONE FOUR-SPINDLE AUTOMATIC

Three features of this machine that will attract attention are: the use of a double-bed construction with the cam-shaft carried by the upper bed, and the machine spindles and tool-slides by the lower bed; the fact that all movements are obtained by flat cams bent to fit cam drums; the arrangement of all operating levers within easy reach of the man in charge of the machine.

IN working out the design of a four-spindle automatic screw machine which has recently been placed on the market by the Cone Automatic Machine Co., Windsor, Vt., the designers have departed from established practice in the design of machines of this type. The Cone "automatic" is styled a "double-bed" machine, and the reason for adopting this name will be apparent from the accompanying illustrations. It will be seen that two beds are provided; the upper bed supports a cam-shaft with cam drums and cams that actuate all parts of the mechanism; and in the lower bed there are provided bearings for the machine spindles, and ways for the slides on which the different types of tools are carried. The best idea of the general arrangement of the mechanism of this machine will be obtained from Fig. 1, but in referring to this illustration the readers' attention is particularly called to the fact that all guards have been removed in order to show the arrangement of cams, gearing, spindles, etc.; Figs. 2 and 4 show the complete way in which all moving parts are covered to provide for the safety of the operator, although in Fig. 2 the hinged gear cover is swung back in order to show the gearing.

Before entering upon a detailed description of the design of the Cone automatic, it will be of interest to present a summary of the features of this machine. It has already been mentioned that all cams are carried on a single cam-shaft at the top of the machine, and in this connection it is important to note that all cams are of the flat type, milled to the desired form and bent to fit on cam drums. This standardization of the form of cams greatly simplifies the setting up of the machine for handling different classes of work. Another important feature is that all the operating levers and wheels are situated at the front of the machine and at such a level from the floor that they may be conveniently reached by the operator. Viewed from the standpoint of accuracy in the product of this machine, prospective users will be interested in the care that has been taken to provide a rigid support for the cross-slides. These are supported by bearings at both the top and bottom, so that deflection caused by pressure of the cut is practically impossible. The top bearings which support the cross-slides against the pressure of the cut are furnished with gibs to provide for compensating for wear, so that it is possible always to have the bearings in perfect adjustment.

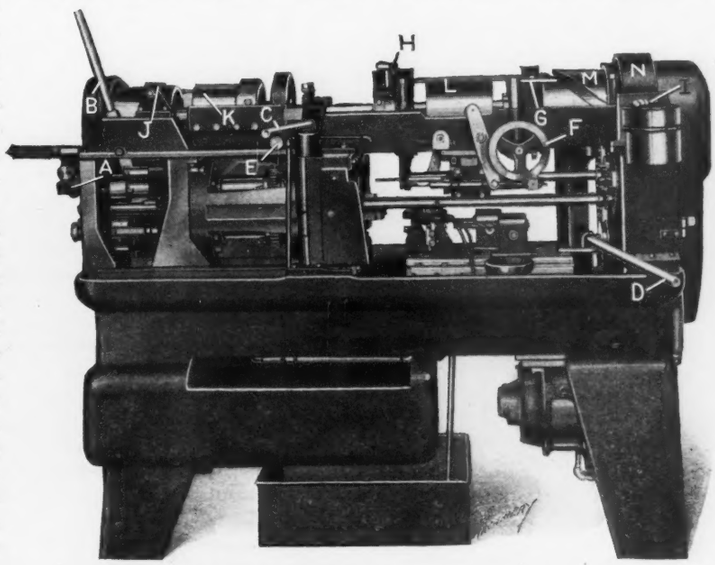


Fig. 1. Cone Four-spindle Automatic with Covers removed to show Arrangement of Cams, Gearing, Spindles, etc.

All heavy turning and forming operations are performed in the two lower positions, so that chips may drop into the pan below the machine without any tendency for them to accumulate on the work, tools and spindle noses; furthermore, these turning and forming tools can be more rigidly supported in the two lower positions, so that it is desirable to have the tools in these positions perform the heavier cutting operations. A patented deflector guides the finished work into a separate receptacle from the chips, and the chip pan is not only of ample proportions, but special arrangements have been made for removing chips from the end of this pan, so that the laborer who performs this work does not interfere with the operator who has charge of the machine.

To provide the desired degree of durability, the Cone automatic is equipped with hardened steel spindles running in phosphor-bronze bearings which may be easily adjusted to compensate for wear. The stock is fed through the upper front spindle, and in this position it is possible to perform drilling, counterboring, reaming or threading operations in addition to cutting off the finished piece. It is claimed that this arrangement brings the finished piece of work into a position where it may be easily inspected

by an operator who is looking after a battery of machines, making it possible for him to ascertain readily that the stock is being fed right up to the stop to produce pieces of full length. In both the third and fourth positions, which are the two upper spindles on the machine, it is the practice to divide up those operations which have just been mentioned; then, my performing turning, forming and similar operations in the first and second positions, *i. e.*, the two lower positions, advantage is taken of adequate tool support and a better arrangement for chip clearance, to which reference has already been made. The tool-slides are heavily built, with plenty of room for a wide range of tool lay-outs, and there is no overhang at the front.

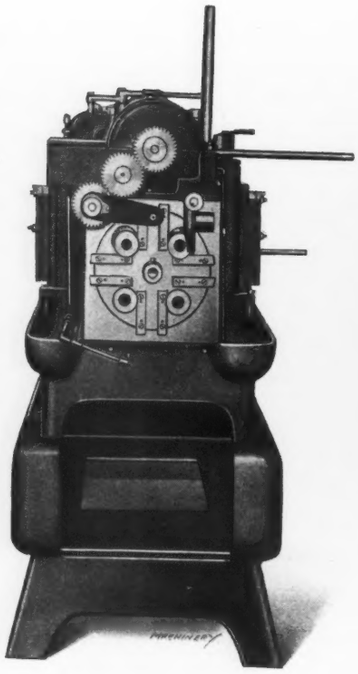


Fig. 3. View of Cone Automatic from Spindle End

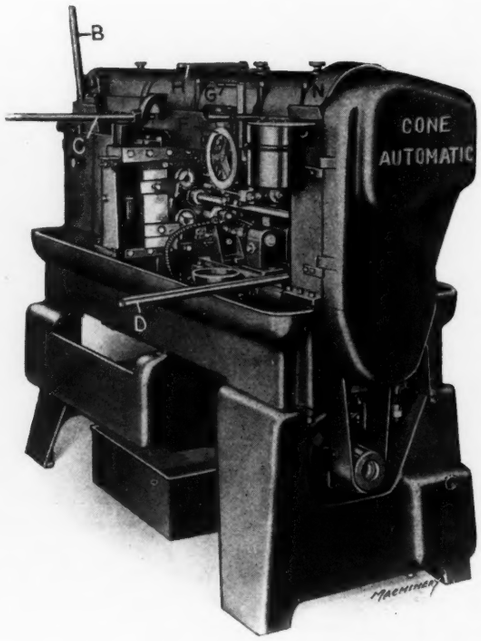


Fig. 4. Arrangement of Spindles, Cross-slides, etc., on Cone Automatic

Arrangement of Operating Levers and Handwheels

Referring to the front views of the machine shown in Figs. 1 and 4, the following outlines the purpose of each of the operating levers and handwheels that are shown. Block *A* is carried on a pivotal support and may be lifted up to disengage the stock feed mechanism. Lever *B* provides for opening or closing the chuck by hand. In setting up the machine, it is often desirable to have means of operating the cross-feed by hand in order to ascertain if the tools are located in the proper positions in the cross-slides. For this purpose lever *C* is provided. When it is desired to operate the cross-feed with this lever, the cam-shaft is rotated backward so that the rollers that run in engagement with the cross-feed cams are no longer in contact with these cams. With the cam-shaft in this position, lever *C* may be pushed back and forth to manipulate the cross-feed at will. Lever *D* provides similar hand adjustment for the tools carried on the slides that run parallel to the machine spindles. Handwheel *F* is carried at the end of a shaft on which there is mounted a worm meshing with a worm-wheel on the cam-shaft. By turning handwheel *F*, provision is made for backward rotation of the cam-shaft so that the cams are moved out of engagement with the rollers in the manner to which reference has been made. Before making this hand adjustment of the position of the cam-shaft, lever *G* is turned; this results in sliding the shaft on which handwheel *F* is carried through the splined worm so that the bevel gear at the opposite end of this shaft is thrown out of mesh with its driving gear, thus disconnecting the power feed. Lever *H* provides for engaging either the fast or slow movement. Lever *C* is a sliding fit in a socket, from which it may be withdrawn and pushed into socket *E* to provide for pulling the turret locking pin when it is desired to adjust the position of the turret by hand. Electrical control on the machine is manipulated by lever *I*. It will be apparent that all these levers are located within easy reach of the operator, so that he is not required to stoop over to reach any of them.

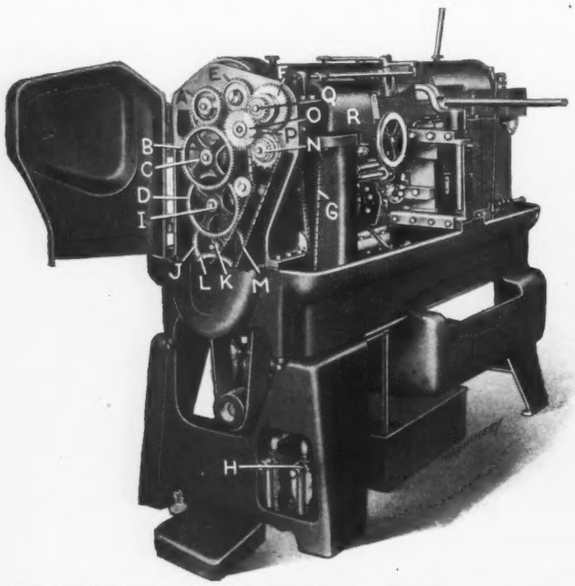


Fig. 2. Cover swung back from Gear-case to show Arrangement of Gears

The Cone automatic screw machine is arranged for single belt drive, the design being worked out in such a way that with a machine of standard design provision may be made for driving from an individual electric motor or from a pulley on the lineshaft. The only difference is that where individual motor drive is employed the electric motor is bolted under the machine and a belt is carried up to the driving pulley shown at *N* in Fig. 1, while a belt is carried down to this pulley from the lineshaft where it is desired to take power from the general transmission system provided in the machine shop. Where individual motor drive is employed, the motor bracket may be raised or lowered as much as two inches by means of a handwheel, which provides for adjusting the belt tension to the desired point. It will be seen that the belt is entirely enclosed except at the top; and that the motor is placed directly beneath the machine and not on the floor; in this way, it is adequately supported and does not take up any additional space in the shop. The main driving shaft is hardened and ground and carried in Hyatt roller bearings.

Power is transmitted from the main driving shaft to the spindle driving shaft by means of compound gearing which provides for obtaining a wide range of spindle speeds. The speed gears are shown at *A*, *B*, *C* and *D* in Fig. 2, and these gears may be changed to obtain the required degree of compounding for any spindle speed which may be required on the work which is performed on the machine. Drive for the pump is taken through gears *E* and *F* and then transmitted through a sprocket chain *G* to the pumps, which are shown in a case *H*, the cover of which has been removed. From the speed gears power is transmitted through reduction gears *I*, *J*, *K* and *L*, and thence through a sprocket chain *M* to the feed gears *N*, *O*, *P* and *Q*. The double reduction gears *I*, *J*, *K* and *L* have a ratio of 16 to 1, and the feed gears *N*, *O*, *P* and *Q* may be compounded to give the desired feed changes. These feed gears are used during the time that the cutting tools are in opera-

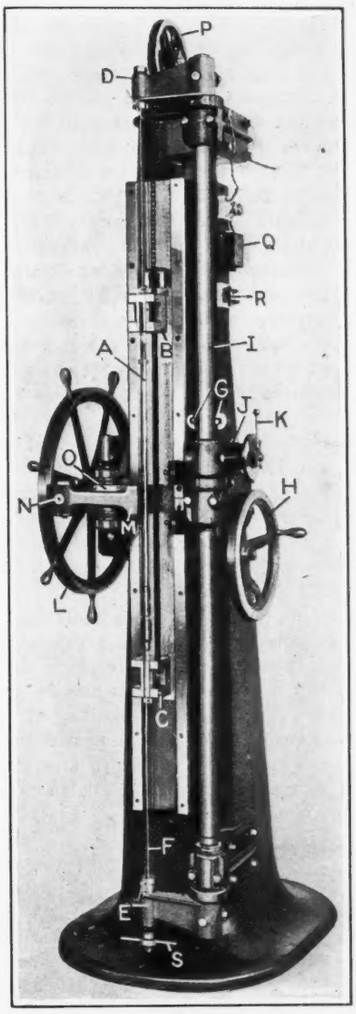
tion. During the idle movement, *i. e.*, while the tools are being backed away from the work, drive to the feed mechanism is through gears *E* and *F* and thence through a quill, on the opposite end of which there is a friction clutch carried in case *R*. This clutch transmits power to the feed mechanism. Attention is called to the fact that all the gears for obtaining speed and feed changes and for driving the pumps are contained in a single case, which affords a design that is practically as compact as it could be made.

Arrangement of Cams on Cam-shaft

Referring to Fig. 1, it will be seen that there is a pair of cam drums at *J*, and the cams on one of these provide for operating the spindle chuck, while the cams on the other feed the stock through the spindle until it reaches the distance stop. At *K* there is a second pair of cam drums, on which there are carried cams that control the operation of the cross-feeds at the front and back of the machine, respectively. A small cam at the right of this pair of cam drums controls the operation of the turret locking pin. A third pair of cam drums at *L* operates the third and fourth position tools, which are opposed to the spindles in the two upper positions. At *M* there is a single cam drum which carries cams that govern the movement of the forming and turning tool-slide on the lower bed of the machine. In conclusion, attention is called to the fact that all oil-pipes for delivering cutting compound to the tools and lubricating oil to the machine bearings are located beneath the bed of the machine, the only exception being flexible tube connections that transmit lubricant from the supply pipes to the cutting tools.

SPONSEL GUN BARREL CALIBRATING AND STRAIGHTENING MACHINE

In order for a gun or rifle to shoot accurately, it is obvious that its barrel must be perfectly straight. After the barrel has been drilled or turned off, it is necessary for it to be straightened several times, and the men who do this work are often given credit for possessing knowledge of certain secret methods. As a matter of fact, it is far more likely that the results they obtain are due to exceptional skill and judgment acquired through years of practice. However, the work of the most proficient barrel straightener is far less accurate than that done by men employed in many other departments of gun shops, as shown by the fact that manufacturers have not been able to accept specifications calling for the bore of a barrel to be straight within less than 0.002 inch for its entire length. While this figure has been regarded as the limit of accuracy in straightening barrels, it is by no means a close limit on many of the classes of machine work involved in the manufacture of guns. Obviously, it would be desirable to have a means of straightening barrels that would enable the work to come within the same limits of accuracy attained in machining gun parts, and such means have been provided in a calibrating and straightening machine which has recently been placed on the market by the Sponsel Co., Inc., 647 Main St., Hartford, Conn. The machine was designed and developed by Charles W. Sponsel, who is known as a designer of machines used for drilling and rifling gun barrels. It consists of a sensitive electrical apparatus for detecting any slight deviation from straightness in the bore, and means of applying pressure to the gun barrel at the point of error so that a permanent "set" will be imparted to the metal at this point to bring the barrel into the desired alignment. Referring to the accompanying illustration of the Sponsel barrel calibrating and straightening machine, it will be seen that a rifle barrel is shown in position at *A*, this barrel being held by plugs which are carried by two adjustable brackets *B* and *C*, which, fastened to a slide, move on ways planed on the machine column. Stretched between arms *D* and *E* there is a wire *F* that runs through the bore in the gun barrel to be tested. A V-shaped platinum "feeler" is carried on this wire, and when this feeler comes into contact with the gun barrel one of the electric lights *G* which are connected in series goes out while the other continues to burn at full voltage; when the feeler is free from contact with the gun barrel both lights burn at half voltage in the usual way. By turning handwheel *H*, movement is imparted to the sliding brackets *B* and *C* so that the gun barrel to be tested is traversed past the feeler carried by wire *F*.



Sponsel Barrel Calibrating and Straightening Machine

It will be seen that the two arms *D* and *E* are carried at the ends of a vertical shaft *I*, and that there is a third arm *J* near the center of the shaft. Shaft *I* is supported in three annular ball bearings, and there is a thrust ball bearing at the bottom, in order that the movement of this shaft may be quite sensitive. The desired oscillatory movement of the arms carried by shaft *I* is secured by a screw that is turned by lever *K;* this screw runs through a nut at the end of arm *J* and bears against the column of the machine, so that by turning the screw, arm *J* is either swung toward or away from the machine, thus imparting movement in the opposite direction to arms *D* and *E*. The length of arms *D* and *E* from the center of wire *F* to the axis of shaft *I* is exactly the same as the length of arm *J* from the axis of shaft *I* to the center of the screw turned by lever *K*. The platinum feeler carried by wire *F* is located so that its knife edge always points directly toward the column of the machine, and when the oscillatory movement is imparted to shaft *I* it results in either moving the feeler toward the wall of the gun barrel or away from it. As previously stated, when this feeler comes into contact with the barrel, one of the lights *G* goes out.

In straightening a barrel the idea is to bring the feeler up almost into contact with the barrel so that both lights are burning; then handwheel *H* is turned so that brackets *B* and *C* are traversed up the column of the machine, which causes the entire length of the barrel to traverse past the feeler. If this traverse is made without extinguishing one of the electric lights *G*, *i. e.*, without the feelers touching the barrel, the feeler is brought closer to the barrel by turning lever *K*, the distance of the feeler from the barrel being indicated by a micrometer dial carried on the screw which is turned by lever *K*. This screw has twenty threads per inch, and the dial is divided into fifty spaces, each of which corresponds to 0.001 inch. At each side of the zero point, two spaces are graduated to 0.00025 inch. Successive traverses of the gun barrel past the feeler are made—and each time the feeler is brought nearer to the barrel—until a point is finally reached where one of the lights is extinguished, indicating contact between the barrel and the feeler. It then becomes necessary to start straightening the barrel to remove the "highest spot" which has been found; but this part of the work will be described later. To be sure of securing accurate results, it is necessary to repeat this sequence of tests, rotating the gun barrel on its centers through the series of tests. In this way it will eventually be found that the feeler can be set within 0.00025 inch of the barrel in any position and the entire length of the barrel traversed

past it without coming into contact. Such a degree of accuracy in straightening would be utterly impossible to obtain, even if the most highly trained barrel straighteners were employed, by the "hammer and eye" methods which are now in quite general use.

In explaining the method of straightening a barrel on this machine, we shall assume a condition where one of the electric lights *G* has just been extinguished, indicating contact between the feeler and the inside of the gun barrel. This indicates a "high point" in the barrel, and to overcome such inaccuracy the operator of the machine simply turns handwheel *L*, leaving the barrel in exactly the same position that it occupies while testing it for straightness. This results in forcing hammer *M* down onto the front of the barrel, this hammer being located opposite an anvil with two supporting points on which the gun barrel is held from the back. In this connection it is important to note that the feeler is always located exactly midway between the two supporting points of the anvil, so that the hammer will descend upon the high point of the barrel, which is detected by the feeler. Pressure applied in this way results in imparting a permanent "set" in the steel, which should be just enough to remove the high spot; but the machine operator can easily make sure that such is the case by subsequent testing with the electrical calibrating apparatus on the machine. In straightening a barrel it is likely to be found that there are a number of high spots—some greater than others—and the machine operator must carefully remove all these high spots as they are found, the highest first, in order to get the bore perfectly straight or at least straight within the limit of accuracy that can be attained with this machine. By this method a barrel can be straightened so that the correctness of the work can be proved mathematically. Furthermore, an unskilled operator can be trained in a few days to do work which it is claimed would be superior to that done by a barrel straightening expert who had spent years in learning the details of his trade.

From the shaft on which handwheel *L* is carried, motion is transmitted to the hammer and anvil through a pair of bevel gears and a shaft *N*, which is threaded right- and left-hand, respectively, in the ends of the hammer and anvil. The hammer is carried on a pivot at *O* and the anvil on a similar pivot, so that when the left- and right-hand threads on shaft *N* are turned in the nuts at the end of the hammer and anvil, these members swing about their pivots so that the barrel is gripped between three points, allowing the hammer to bend the barrel between the two-point anvil to remove the high spot. A compensating mechanism is provided so that in case either the hammer or anvil engages the barrel too soon, pressure will not be applied until the two supporting points of the anvil and the hammer are in contact with the gun barrel. During the operation of straightening, both ends of the barrel naturally move outward away from the column, and to accommodate this movement the plugs supporting the barrel are secured in hinged members, which normally are held in an aligned position by a spring.

Obviously it is of the greatest importance to have the machine set up so that the plug centers carried by sliding brackets *B* and *C* are in accurate alignment with each other, and also in alignment with the ways on the column of the machine in two planes. This result is obtained by substituting a test bar in place of the rifle barrel *A*. The bar is drilled and carefully reamed to correspond to the bore of the rifle barrel to be tested, and then accurately ground on the outside so that it is true with the bore. This bar is set up on the plug centers, after which a dial test indicator is mounted on a bracket bolted to the column of the machine. The bar is traversed past this indicator with the latter in contact with first the front and then the side of the bar. Adjustments are made until the test may be conducted without deviation of the indicator. This shows that the bar is parallel with the ways on the column of the machine in two planes, and hence that the plug centers on which the bar is supported are in accurate alignment with each other and with the machine ways.

In conclusion, the reader's attention is called to several interesting details of design on this machine. Sliding brackets *B* and *C*, on which the gun barrel is supported, are connected by a cast-iron slide, and the entire weight of these members and the gun barrel is counterbalanced by a weight hung on sprocket chain *P*. This chain extends down behind the slide that connects brackets *B* and *C*, forming a rack that meshes with a sprocket wheel carried on the same shaft with handwheel *H* that provides for traversing the sliding brackets. This is a simple and inexpensive way of making a rack. Ordinarily the current used for electric lights *G* is taken from an ordinary illuminating circuit and passed through transformer *Q* so that the E.M.F. is reduced to six volts. The reason for this reduction in voltage is to avoid the danger of an operator receiving an electric shock while working on the machine. As there is always a possibility of interruption in electric service from a central power station, a battery of four dry cells is carried on a shelf inside the machine column, and these batteries may be connected to the electric lights *G* by reversing the position of double-throw switch *R*. In one respect the machine shown in the accompanying illustration has been modified. Originally a hand-screw *S* was employed to put the necessary tension on the wire *F* after it had been threaded through the gun barrel and secured in the chuck carried by arm *E*. This tension is necessary in order to keep the wire taut and also to be sure that the edge of the feeler is pointed constantly in the same direction. An improvement in the arrangement for applying tension to wire *F* has been provided by substituting a quick-acting cam mechanism for hand-screw *S*. This cam stretches the wire ½ inch and applies a tension of approximately 300 pounds in the wire, so that accuracy is insured.

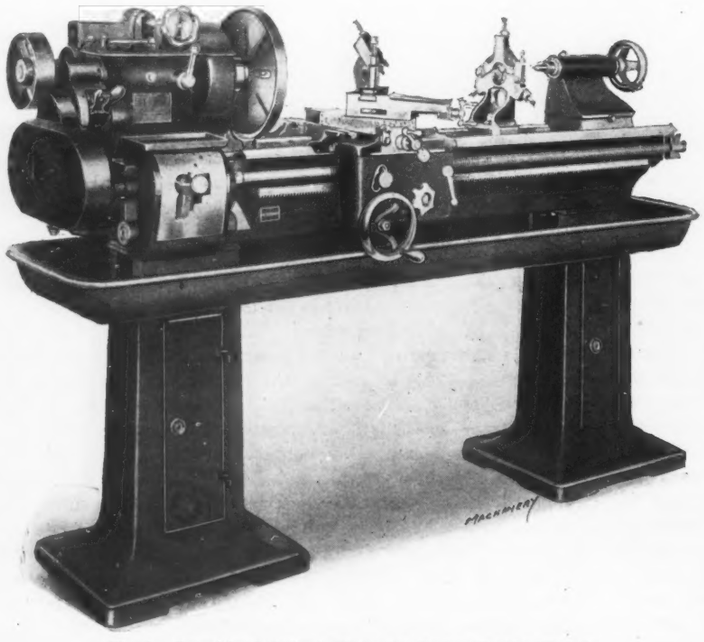


Fig. 1. Geared-head Lathe built by the Master Machine Tool Co.

MASTER ENGINE LATHES

The Master Machine Tool Co., 110-112 W. 40th St., New York City, has added to its line the two lathes illustrated and described herewith. It will be apparent that the design of these machines is essentially the same except that the lathe illustrated in Fig. 1 is provided with a geared head, while the machine shown in Fig. 2 has a cone head; also, the geared-head machine is furnished with an oil-pan and cabinet legs. With the exception of the features to which particular reference has been made, the following description will apply to both machines.

These lathes are intended for use in tool-rooms and on manufacturing work where accurate ma-

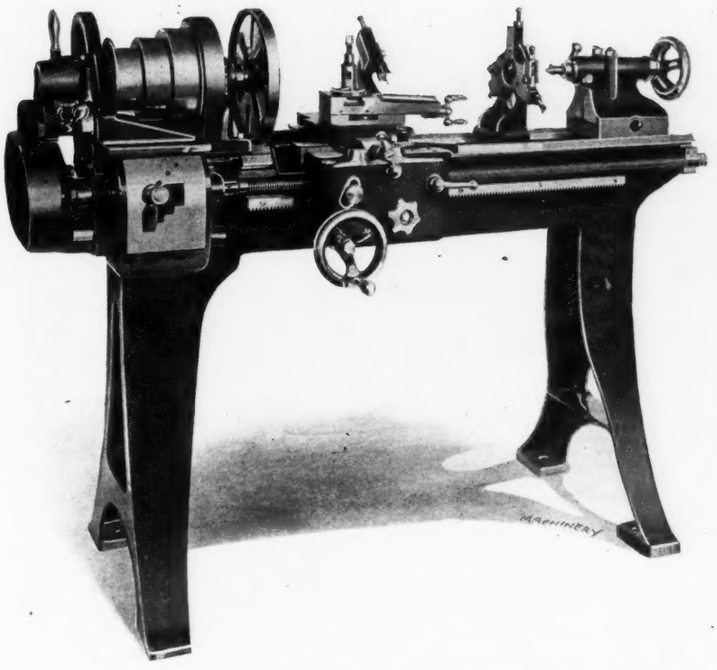


Fig. 2. Lathe with Cone Pulley and Back-geared Drive built by Master Machine Tool Co.

chining is required. The bed is designed with two wide-spread vees and two flat bearing surfaces, and is supported by cross-braces to reduce vibration to a minimum. The splined lead-screw is set immediately below the guides to obtain a steady motion for the carriage. The spindle is made of special carbon steel, accurately ground to size, and it has a hole through the entire length of ample size to take draw-in attachments and collets. The spindle runs in phosphor-bronze bearings, the large end being threaded to receive chucks and faceplates. There are two adjusting collars for taking up wear. Special means are provided for carrying the end thrust, so that smooth operation is insured under heavy cuts.

The apron is simply designed, with a detachable back-plate that allows the removal of all parts for repair or inspection. The lead-screw is splined for driving the worm which operates the automatic longitudinal- and cross-feeds through a friction clutch. It is impossible for both feeds to be in operation at the same time, as a safety lever prevents engaging the split nut while either feed is in use, thus making the lathe practically fool-proof. The accurately milled thread of the lead-screw is only used for screw-cutting operations, so that the life of the screw is prolonged. The four-change feed-box has steel gears and provides for instantaneously obtaining the usual changes of feed, as, for instance, where it is desired to change from roughing to finishing. Threads are cut through the feed-box as indicated on the gear plate. Regular equipment furnished with the machines consists of a countershaft, large and small faceplates, follow-rests and fixed steady-rests, change-gears, and the necessary wrenches for making all adjustments.

On the geared-head lathe shown in Fig. 1 the headstock is equipped with all steel gears, which provide six changes of spindle speed ranging from 28 to 418 revolutions per minute. Drive is through a positive clutch. The headstock is secured to the bed by two ¾-inch bolts. Changes of spindle speed may be easily and rapidly obtained by means of a lever and a hand-wheel conveniently located on the headstock. The changes are so arranged that no two speeds can be engaged at the same time. All gears are completely enclosed and run in oil. On the cone-driven lathe illustrated in Fig. 2, the headstock is secured to the bed by three staybolts. This headstock is of the back-geared type, and the three-step cone pulley carries a belt two inches in width.

"RED-E" TOOLS

The Ready Tool Co., Bridgeport, Conn., has added to its line what are known as Types X4 and X5 tool-holders. These are the regular "Red-E" chrome-nickel tools made in large sizes to meet the demand for such tool-holders. The Type X4 holder takes a ½-inch square tool bit, and the Type X5 holder takes a ⅝-inch square bit. The inserted half-round section of tool steel electrically welded in place, which is a well-known feature of "Red-E" tools, is provided in these tool-holders, thus preventing wear at a vital point. The set-screws are made of carefully selected steel and are not likely to break. A special process of heat-treatment makes the holder hard on the outside and tough on the inside, so that it will not "mash" down on the top. The tool-holder is a chrome-nickel steel drop-forging.

"AMTEW" ENGINE LATHE

The American Machine Tool Engineering Works, 4854-4858 W. Kinzie St., Chicago, Ill., are now building the "Amtew" 14-inch high-power engine lathe illustrated and described herewith. One of the important features of this lathe is that in the apron there are four changes of cross- and longitudinal-feed, any of which can be obtained by simply moving the feed-change lever to one of four positions, which constitutes a quick and efficient means of making changes of feed. A back-gear shifting lever makes it possible to change the speed of the machine from the lowest range to the intermediate range of speeds without loss of time. The feed-rod is driven direct from within the headstock by a train of gears and an overload friction, no feed belt being employed. Overloading the feed by accident simply causes the friction to slip, thus preventing damage to the mechanism.

The headstock is of the bowl type, and the spindle is made of 60-point carbon crucible steel. The front spindle bearing is 2 7/16 inches in diameter by 4 inches long, and the spindle is bored to hold a bushing bored for No. 3 Morse taper. The spindle bearings are lined with bronze and accurately scraped to fit the spindle. All gears subjected to severe service are made of steel and the idlers are bushed with bronze. The tailstock spindle is made of exceptional length, which gives ample rigidity as well as provision for drilling unusually deep holes with a twist drill without having to move the tailstock. The tailstock spindle is 1¾ inch in diameter and has a maximum

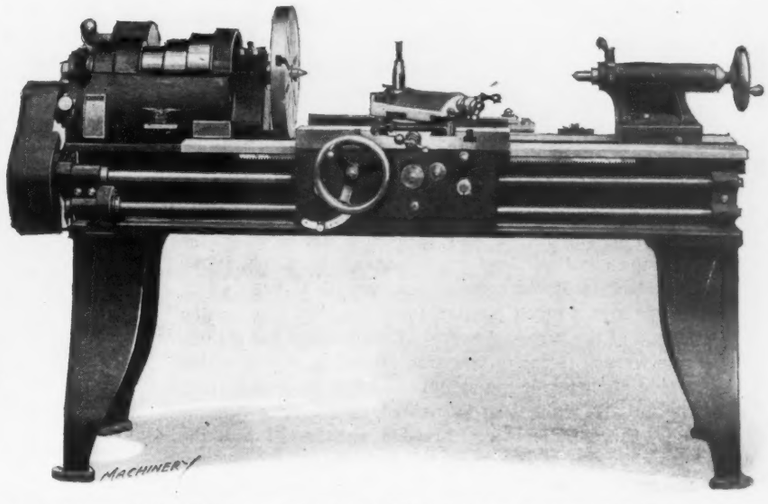


Fig. 1. "Amtew" 14-inch High-power Engine Lathe built by American Machine Tool Engineering Works

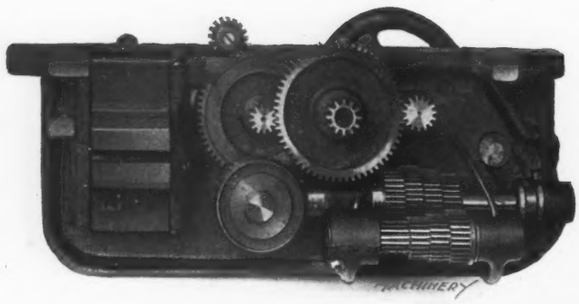


Fig. 2. Rear View of Apron, showing Arrangement of Feed Change-gears

travel of over 8 inches. The carriage has a bearing 23 inches long on the ways, and the carriage bridge is 7¼ inches wide. The apron, including its bearings, is cast in one piece, and a safety device makes it impossible to throw in the half-nuts when either feed is connected. Mention has already been made of the fact that the feed change is located in the apron. The principal dimensions of this lathe are as follows: swing over ways, 14 5/8 inches; swing over carriage, 7 inches; distance between centers for six-foot bed, 36 inches; taper of centers, No. 3 Morse; diameter of hole through spindle, 1 5/16 inch; range for thread cutting, 1 to 48 threads per inch; cone pulley diameters, 5 1/2, 6 1/4 and 8 inches; width of belt,

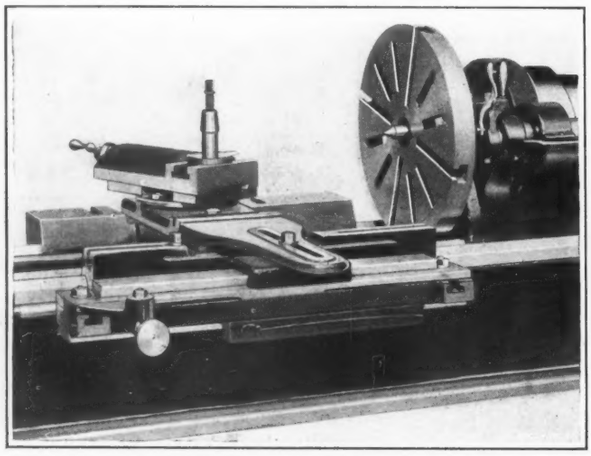


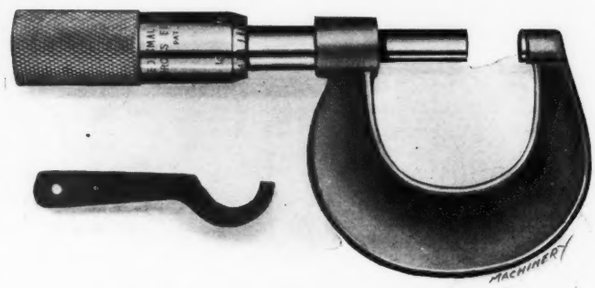
Fig. 3. View of Taper Attachment and Carriage from Back of Lathe

2 1/2 inches; ratio of double back-gears, 3 to 1 and 8 to 1; number of spindle speeds, 18; range of spindle speeds, 30 to 655 R.P.M.; and weight of machine with six-foot bed, 1600 pounds.

REED MICROMETER CALIPER

Micrometer calipers manufactured by the Reed Small Tool Works, Cherry and Vine Sts., Worcester, Mass., are provided with means of adjustment for any wear that may develop on the ends of the anvil and spindle by having the thimble made in two separate parts. The sleeve and knurled section are held together by friction in such a way that the sleeve may be rotated in either direction by the use of the small spanner wrench shown beside the micrometer. This constitutes a simple method of adjusting, by which it is an easy matter to bring the zero mark on the sleeve and the horizontal division line on the barrel of the micrometer into coincidence when the spindle and the anvil surfaces are together, or when a standard testing block is placed between the spindle and the anvil. The same spanner wrench is used for taking up the tension nut at the end of the threaded barrel to compensate for spindle wear. This wrench is cut to two arcs of circles, one of which is the outside diameter of the spindle and the other the diameter of the nut. A rigid joint is insured between the thimble and spindle, the spindle being threaded and locked into the knurled thimble.

This micrometer has the frame made of drop-forged steel and is provided with a dull nickel finish. It is so designed that it "hangs" well for the machinist, who will appreciate the deep throat, allowing plenty of finger room, and the concaved frame, which affords a natural finger grip. By making the anvil stationary, it has been found possible to reduce the width of the frame at this point, thus adapting the micrometer for working in close places. The tool is compact, and the design has been worked out so that the number of parts has been reduced as far as possible. These micrometers are graduated to 0.001 inch and are made in six sizes, ranging from one to six inches; each size of micrometer has a range of one



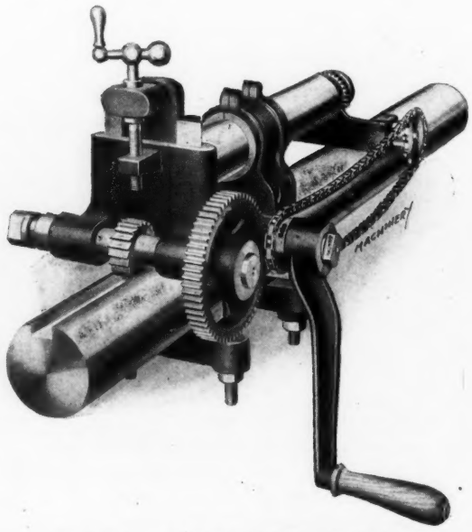
Micrometer Caliper made by Reed Small Tool Works

inch. Micrometers of corresponding sizes are also furnished for making metric measurements, and a lock-nut can be furnished with either type.

BUCHER-SMITH PORTABLE KEYSEATER

In the accompanying illustration is shown a portable keyseater which is a recent product of the Bucher-Smith & Co., Ravine St., East Liverpool, Ohio. This machine is so designed that it may be driven by a hand crank, or this crank may be removed and the machine driven by a one-fourth-horsepower electric motor. Five milling cutters are furnished with the machine, which may be ganged in various combinations to provide for cutting keyseats from ¼ to 1¼ inch in width. Keyseats may be cut in shafts from 1¼ to 5 inches in diameter, and the capacity of the machine is for cutting keyways up to 12 inches in length without requiring the machine to be reset.

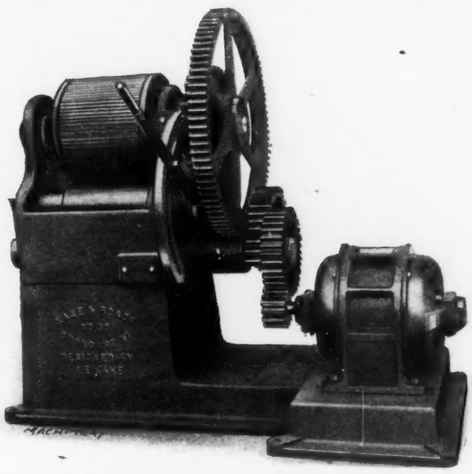
This machine has been designed to meet the requirements of mechanics, millwrights and repair men in mills, mines, factories, etc. The feed-screw is located inside the spindle, which brings the pull very close to the shaft. Provision is made for disengaging the feed mechanism by a sliding clutch at the rear of the spindle. The use of a portable machine of this type, which may be taken to the work and used without requiring much disassembling, is often the means of saving a substantial part of repair costs.



Portable Keyseater built by Bucher-Smith & Co.

KANE & ROACH TUNNEL PLATE BENDER

One of the recent additions to the line of machines built by Kane & Roach, Niagara and Shonnard Sts., Syracuse, N. Y., is the No. 35 tunnel plate bender illustrated and described herewith. This machine is adapted for bending special work, such as wide channels made from light sheets, *i. e.*, sheets with flanges turned up at each side. It is especially suitable for

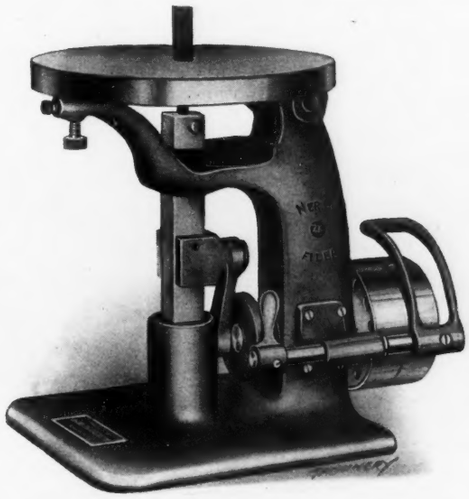


Tunnel Plate Bending Machine built by Kane & Roach

use where plates are to be bent with the flanges on the inside of the circle. After the tunnel plates have been produced on the machine in this way, they are bolted together by the flanges to form sections of the desired length.

NEWARK FILING MACHINE

The Newark Engineering & Refrigerating Co., 476 18th Ave., Newark, N. J., is now building the "Nerco" filing machine, which forms the subject of the following description. It will be apparent from the illustration that this machine is of simple but rigid construction. The machine is provided with a square shaft, which runs in two babbitted bearings that fit closely, so that side motion is practically eliminated. This does away with tendency to under-cut when working to finish lines. A table is provided which is of ample size to handle a great variety of work, and the adjusting and locking screws enable the table to be set accurately to the desired angle. The principal dimensions of the machine are as follows: diameter of table, 8 inches; height of table from bench, 10 inches; total width of machine, 8 inches; total length of machine, 12 inches; diameter of tight and loose pulleys, 3½ inches; width of driving belt, 1 inch; and net weight of machine, 22 pounds.



"Nerco" Filing Machine built by Newark Engineering & Refrigerating Co.

Fig. 1. Type of Inserted-cutter Tool made by Lovejoy Tool Co.

LOVEJOY INSERTED-CUTTER TOOLS

In working out the design of its line of inserted-cutter tools, the purpose of the Lovejoy Tool Co., Inc., Springfield, Vt., has not been to develop universal holders having adjustments to cover all positions that might be required for toolmaking, and which are only occasionally used, but rather to design production tools that closely approach solid forged tools as regards rigidity and freedom from unnecessary overhang and objectionable projections. The cutters are made of high-speed steel and are carefully heat-treated by a method that insures satisfactory results. All cutters are made to gage measurements so that they are interchangeable in their respective holders. As a result, it is possible to order cutters and be sure that they will be ready to begin work when received, because they are sure to fit properly in the holders and they are heat-treated ready for service.

The turning, facing and planing tools included in this line are of a positively locked type, the tool thrust being taken on

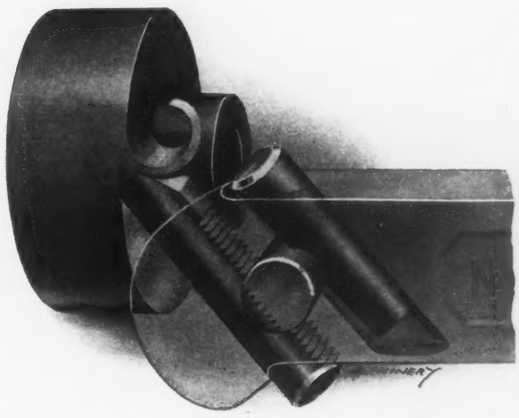


Fig. 2. Phantom View of Head of Lovejoy Inserted-cutter Tool

the locking key, which, in turn, takes its seat on the solid metal of the holder. The vertical locking wedge only serves to bind the cutter in position, making it virtually a part of the holder. It is claimed to be impossible for the cutter to slip while taking heavy intermittent cuts. Height adjustment is provided for the cutters as they become worn, so that the maximum amount of service is obtained. The toolholders are carefully heat-treated and capable of withstanding the heaviest strain imposed by high speeds and feeds.

It is claimed by the manufacturers of these tools that a tool taking the cutting thrust approximately in the direction of its length is more serviceable from the standpoint of durability under heavy cuts than a tool of equal size taking the strain at right angles to its length. This, of course, assumes that the tool is securely held in the holder. By reducing the strain in the cutters, it has been found possible to harden them to a high degree of cutting efficiency. Although the nature of boring operations does not make it possible to work under the superior conditions obtained in the performance of turning and facing operations—in so far as the relation of the cutters to the work is concerned—the cutters are placed in such a position in boring-tool holders that they receive as nearly as possible an end thrust and natural top rake. Grinding is done entirely on the end and the tools are locked in their holders with a total absence of protruding set-screw heads, thereby giving unobstructed chip clearance from the holes when they are only slightly larger than the boring-tool holders.

SWIND COLD SAW

The Swind Machinery Co., Widener Bldg., Philadelphia, Pa., is now building a cold saw that has a cutting capacity for work up to 3¼ inches in diameter. This machine is of compact design, so that it takes up a relatively small amount of room, which is an important factor in shops where floor space is at such a high premium that it is desirable to utilize out-of-the-way corners for cold saws and similar equipments. It will be apparent that the chief point of interest in connection with the design of this machine is the means which have been provided for feeding the saw to the work. The shaft on which the saw is carried is eccentrically mounted in a cylindrical frame which is furnished with means for giving it an oscillatory movement, as a result of which the saw is fed through the work to be cut off. The saw is automatically fed into the work.

The way in which the feed mechanism operates will be best understood by reference to Fig. 2. Here it will be seen that there is a bellcrank carrying two pawls that engage a ratchet wheel. These pawls and the bellcrank on which they are carried are actuated by means of a link, adjustment of the number of teeth picked at each stroke, and consequently of the

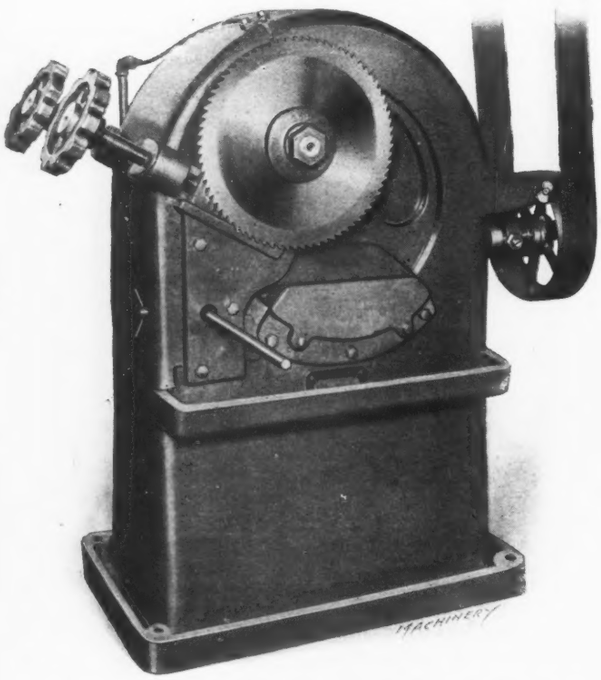


Fig. 1. Cold Saw built by Swind Machinery Co. for Work up to 3¼ Inches

rate at which the saw is fed into the work, being regulated by changing the position of the crankpin in the slotted disk provided for that purpose. At the opposite end of the shaft on which the ratchet wheel is carried, there is a pinion that meshes with an arcuate rack secured to the frame of the machine. As the pinion rotates in mesh with this rack, it will be apparent that the cylindrical frame carrying the saw is rotated, thus causing the saw to be fed into the work. It will be seen that there is a short arm carried by the cylindrical frame that carries the saw. This arm may be set so as to trip a clutch on the driving shaft when the saw has completed its cut.

Since taking the photographs from which illustrations were made for use in connection with this article, some minor changes have been made in the design of the machine. The pump is placed on the inside of the column, which has improved the arrangement of the pipe connections considerably, making it possible for the pipe to be connected so that it extends up from the pump to the top of the machine without requiring the angle and T-connections which are shown. The reservoir has been considerably enlarged and a hand-hole

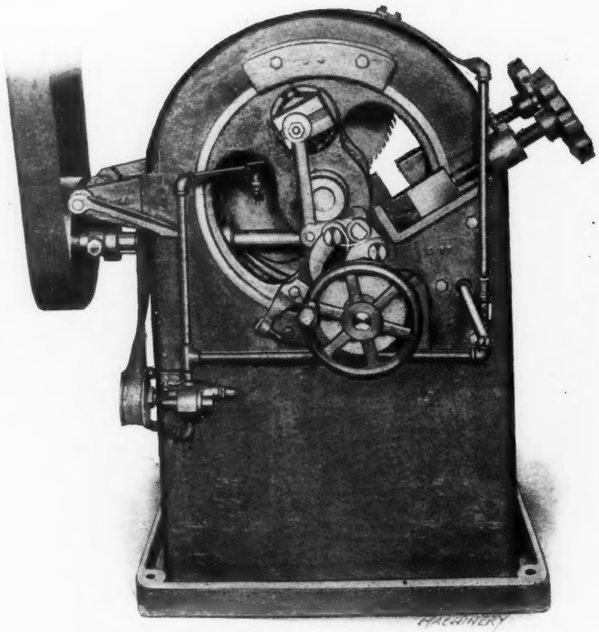
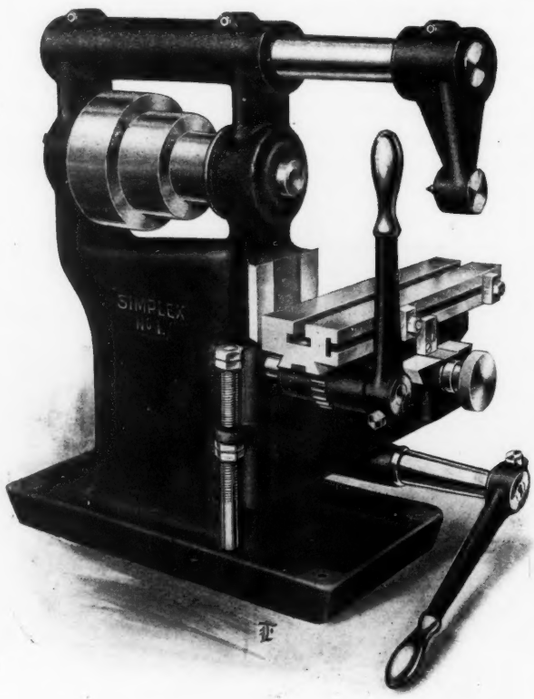


Fig. 2. Opposite Side of Machine, showing Feed Mechanism and Automatic Trip

has been provided at the front of the machine, making it possible to clean out the oil retainer thoroughly. The use of an oil channel around the base has also been discarded.

WRIGHT HAND MILLING MACHINE

In the accompanying illustration is shown a machine known as the "Simplex" hand miller, which is a recent product of David A. Wright, 568 Washington Blvd., Chicago, Ill. This machine is adapted for milling small parts, such as those that are machined in factories manufacturing typewriters, guns, sewing machines, etc. The overhanging arm is two inches in diameter and can be adjusted horizontally to accommodate different lengths of arbors, or it can be swung out of the way when desired. All sliding bearings are provided with gibs to afford means of compensating for wear. The cross-feed knob



"Simplex" Hand Milling Machine built by David A. Wright

is graduated to 0.001 inch and adjustable stops are furnished for both the table and knee. As shown, this machine is arranged to be set up on a bench, but to meet the requirements of shops that desire to use it as a floor type machine, a pedestal base is furnished to which the bench machine may be bolted.

The principal dimensions are as follows: size of working surface of table, 3½ by 13 inches; maximum table cross-feed in line with spindle, 3¼ inches; maximum table longitudinal feed, 6½ inches; maximum vertical adjustment of knee, 5¼ inches; distance from arm to center of spindle, 5½ inches; maximum distance from center of spindle to table, 5¼ inches; width of T-slot, ½ inch; taper of spindle, B. & S. No. 8; diameter of hole through spindle, 11/16 inch; available spindle speeds, from 100 to 1200 R.P.M.; speeds of two-speed countershaft, 200 and 600 R.P.M.; size of countershaft pulleys, 2¼ by 6 inches; weight of bench miller, 250 pounds; and weight of bench miller on column, 400 pounds.

DETROIT SENSITIVE DRILLING MACHINES

To provide for drilling holes up to ⅜ inch in diameter on production work, the Detroit Tool Co., 1487 St. Antoine St., Detroit, Mich., is now manufacturing Model L-1 high-speed sensitive drilling machines which are shown in the accompanying illustrations. These machines are made in both floor and bench types, a front view of the floor type machine being shown in Fig. 1 and a rear view of the bench machine in Fig. 2. Except for the fact that one machine is furnished with a pedestal base, both are of essentially the same design, so that the following description applies to both types. Power is transmitted from the tight pulley through rawhide and steel bevel gears to a straight vertical shaft, at the top of which there is an aluminum pulley. From this pulley a straight belt with an idler pulley to maintain the desired tension, transmits power to a two-step aluminum pulley on the spindle.

Fig. 1. Front View of Detroit Floor Type Sensitive Drilling Machine

The straight driving pulley permits of making quick changes from one to another of the steps on the spindle cone pulley, the difference in belt length for these two steps being taken up by the idler pulley operated by a handwheel, screw and idler lever. With this arrangement more belt contact surface is obtained on the cone pulley when running on slow speed. The belt shifter is located on the same side of the machine as the handlever. If it is necessary to shift the belt from the large to the small cone, the operator merely lets go of the lever and raises his hand about a foot to reach the belt shifter, with which he shifts the belt onto the small step on the cone. The spindle is then free to back up and rise out of a troublesome burr, etc.; then by pulling down the belt shifter the spindle is immediately in motion again. The whole operation only takes a second and the operator is not required to touch the belt. His left hand is on the work or jig all the time. The driving belt is 1¼ inch in width and is made of woven fabric. The machine is adapted for speeds up to 8000 revolutions per minute.

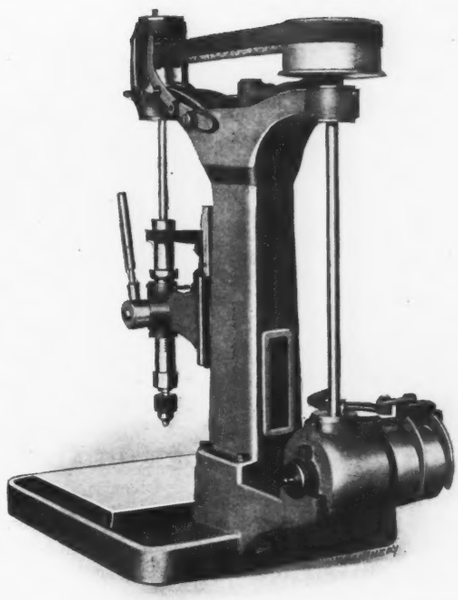
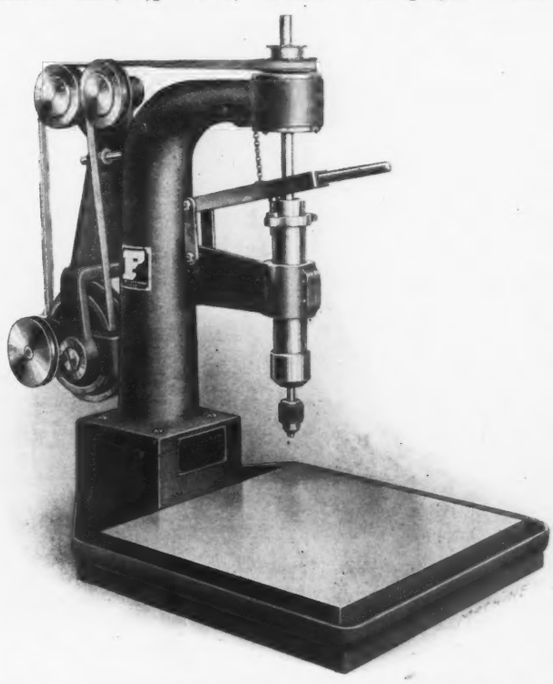


Fig. 2. Rear View of Detroit Bench Type Sensitive Drilling Machine

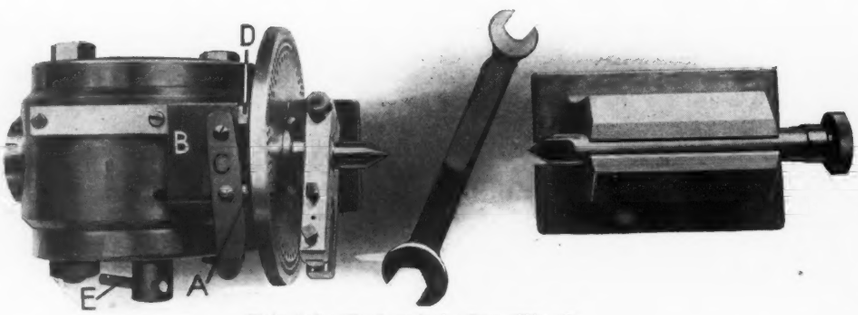
FENN HIGH-SPEED DRILLING MACHINE

In the high-speed sensitive drilling machine that has recently been developed by the Fenn Mfg. Co., 385-405 Broad St., Hartford, Conn., a departure has been made from the usual method of feeding the spindle through a rack and pinion. On this machine it will be seen that the feed movement is obtained with a lever direct connected to the spindle sleeve. The weight of the lever, sleeve, spindle and chuck is counterbalanced, thus permitting the operator to know just what pressure he applies to the point of the drill. This drilling machine is adapted for a maximum speed of 15,000 revolutions per minute, and it is fitted throughout with SKF ball bearings. The principal dimensions are as follows: distance from chuck to table, 5¼ inches; distance from upright to center



High-speed Drilling Machine built by Fenn Mfg. Co.

of spindle, 6½ inches; size of table inside oil-groove, 13½ by 13½ inches; maximum feed movement, 3 inches; available spindle speeds for a countershaft speed of 965 R.P.M., 7735, 9285, 12,500 and 15,000 R.P.M.; diameter of tight and loose pulleys, 4¼ inches; and weight of bench machine without countershaft, 140 pounds.



Plain Index Head made by Secor Mfg. Co.

SECOR PLAIN INDEX HEAD

The index head illustrated is a recent development of the Secor Mfg. Co., Derby, Conn. Its construction is essentially simple and it is for use on milling machines or other machines on which any indexing is required except that which combines spiral work. The complete index head comprises the headstock, tailstock and wrenches as shown. The tailstock is of rigid construction, the base being made of cast iron, while the moving parts are made of hardened steel. The tail-center is turned eccentrically, and, in addition, is slightly flattened on top, making it possible to mill very close to the center of the work.

The index head itself is regularly furnished with one dial containing three rows of holes of 80, 72 and 42, respectively. This combination gives a great deal of leeway and can be divided into any ordinary number of spacings. Great accuracy is employed in making these plates and each hole is lapped, causing the index-pin to fit nicely. The index-pin *A* slides freely in the swiveling block *B*, and is operated by the hand-lever *C*. By loosening the nut *D*, the block is free to swing through a sufficient arc to cause the index-pin *A* to engage in any one of the three circles of holes, where it is rigidly clamped. In addition to the use of the index-pin in preventing rotation, a binding handle *E* is provided, which securely binds the spindle and relieves the thrust of the working tool from the index-pin.

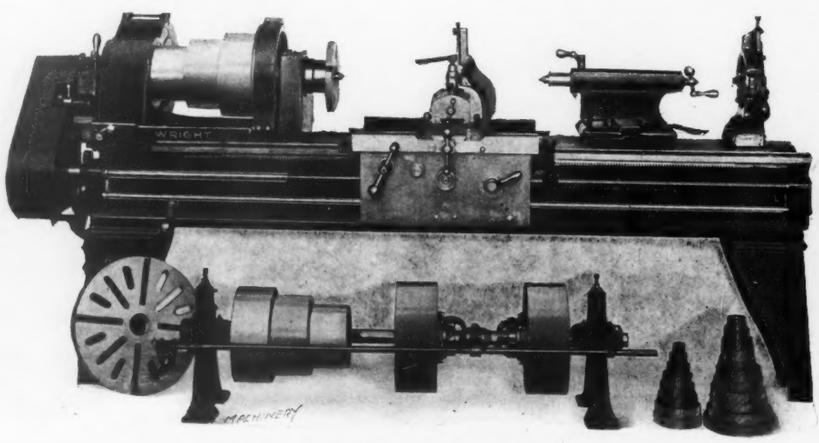
The center, instead of fitting directly into a taper in the spindle, fits a hardened steel collar, which, in turn, fits into the spindle. On this collar is carried the dog driver, which fits the collar snugly but is split and equipped with a binding screw, so that fractional spacings may be secured, such as when a partially finished piece of work is being returned to the centers. Instead of the dog on the work being bound to the driver by a simple screw, a block is furnished that is rounded on its edge so that a line contact is secured between it and the dog. This is desirable in ordinary work, but is especially desirable when the head is set for tapered work.

The dividing head is of the tilting type, accurately graduated in degrees in a position on the body where the readings are plainly visible. When the head is tilted, it is rigidly clamped by the two generously proportioned bolts shown. This part of the head is constructed of three iron castings, the base, the two side plates and the tilting body. The remaining parts are chiefly made of hardened steel; and the spindles, etc., are accurately ground. The head is equipped with double-end wrenches, fitting all the nuts and screws in use on the head. The construction is plain and durable, with no unnecessary finish.

WRIGHT ENGINE LATHES

In the accompanying illustration there is shown a back-geared engine lathe which is built in 18- and 20-inch sizes by David A. Wright, 568 Washington Blvd., Chicago, Ill. This machine is of the independent change-gear type and is built single or double back-geared. The bed has three vees and one flat way, which assures adequate support for the carriage. The headstock has a three-step cone pulley that carries a 5-inch belt. This cone pulley and spur gear can be instantly connected or disconnected by an improved locking device which does not require the use of a wrench, and permits of rapid engagement or release of the back-gears. All exposed gears on the machine are covered by removable guards. The spindle has a hole 1⅝ inch in diameter through its entire length and is furnished with special means of lubrication, which consist of oil reservoirs placed under both spindle boxes with chains to carry oil up to the bearings. This insures constant lubrication at all times when the lathe is in operation. Oil pockets are provided in the cone pulley which provide lubrication when the pulley is revolving around the spindle Phosphor-bronze bushings are provided for the spindle bearings, and anti-friction thrust bearings are furnished with an adjusting nut and steel thrust washers which reduce friction to a minimum. The tailstock is designed with a curved front, which allows the compound-rest to be used at right angles to the cross-feed.

On this lathe the carriage is securely gibbed at the front, center and back. Power longitudinal- and power cross-feeds are provided. There is a micrometer adjustment on the cross-feed screw, and when the cross-feed is used the carriage can be quickly clamped to the bed by a conveniently located lever. A chasing dial is provided. The compound-rest is fitted with taper gibs which require only one screw for their adjustment, and means are provided for removing the handle of the compound-rest so that it does not interfere with the cross-feed handle. Both the longitudinal- and cross-feeds are reversible from the apron, with the mechanism so designed that it is impossible for the lead-screw and feed-rod to be engaged at the same time. Feed reverse is controlled by a lever placed near the bottom of the apron at the right-hand side, this device being used for the control of turning feeds but not for screw cutting. The reverse for screw cutting is obtained by shifting a lever which is conveniently located at the end of the head-



Engine Lathe built in 18- and 20-inch Sizes by David A. Wright

stock. Great care is taken in cutting the lead-screw, and the lead-screw nut is of the usual split pattern and lined with babbitt metal. The feed-box is placed directly beneath the headstock and so arranged that by shifting a lever four changes may be easily obtained. When not required, this device may be disconnected by shifting a small lever at the bottom of the headstock. The gear-box is so designed that changing the gear on the shaft coming directly from the box enables any desired speed to be obtained. A double friction countershaft is furnished as part of the regular equipment, this countershaft having large pulleys which run on self-oiling bushings. Included in the regular equipment there are also a compound rest, steadyrest, follow-rest, large and small face-plates, change-gears, and the necessary wrenches for making all adjustments.

VAN NORMAN AUTOMATIC BORE GRINDER

For the rapid and accurate grinding of short, straight or taper holes the Van Norman Machine Tool Co., Springfield, Mass., has added to its line a No. 34 automatic bore grinder which is illustrated and described herewith. A feature of this machine is economy of floor space, which is made possible through the provision of special means for withdrawing the work from alignment with the grinding spindle for gaging. This is done by means of a cross-slide, which enables the work-head to be pulled forward after the grinding spindle has been withdrawn from the work. In this way a plug gage may be used without having to back the work-head a considerable distance away from the wheel.

Fig. 1 shows the work-head drawn back from the wheel for gaging the work, while in Fig. 2 the wheel is shown in the operating position. Withdrawal or return of the wheel from the work and the work-head from alignment with the wheel-spindle, is effected by means of the two hand-levers shown. Both levers are provided with locking devices, that on the wheel-slide serving to secure it to a subslide which is in constant connection with the operating mechanism. Gripping the wheel-slide lever with the right hand disconnects the operating mechanism, and movement of this lever withdraws the wheel from the work. This lever is manipulated with the right hand, and with the left hand the operator swings over the lever that draws the work-head out of alignment with the wheel-spindle. Gripping of this lever is also responsible for first withdrawing the locking device, while further movement causes the work-head to be drawn forward. It is not necessary to disconnect the cross-feed while making these adjustments.

This grinder was especially designed to meet the requirements of ball bearing manufacturers for a machine adapted for grinding short straight or taper holes of various diameters. It is provided with a cross-feed mechanism of the same refinement as that employed in the Van Norman oscillating or radius grinders. The automatic cross-feed for the wheel-spindle is equipped with a fine graduated dial and adjustable cut-out latch device. Hand feed for the wheel-spindle is operated with a handle when the automatic mechanism is disconnected from the dial. Automatic table traverse gives any variation in the length of stroke from ⅛ to 1⅝ inch, and there is also hand table feed operated by a lever that actuates a rack and pinion and gives a traverse movement of the table up to 4½ inches. The work-head cross-slide is operated by a hand-lever that carries the head crosswise from the center of the wheel-spindle in the manner previously described. The maximum movement available is 4½ inches. Owing to the convenience of operation and the accuracy of the feed mechanism, several machines may be looked after by a single operator. Machines of this type are furnished either with or without water equipment.

The principal dimensions are as follows: capacity for handling work from the smallest up to 4 or 5 inches internal diameter; distance from floor to center of wheel-spindle, 44 inches; number of table traverse speed changes, 4; number of wheel-spindle speed changes, 4; number of work-head speed changes, 4; and weight of machine, approximately 1850 pounds. A countershaft and the necessary wrenches for making all adjustments are furnished as part of the regular equipment.

SIMMONS DRILLING AND TAPPING MACHINE

In the July, 1917, number of MACHINERY a description was published of a bench type automatic tapping and drilling machine that had just been placed on the market at that time by W. H. Simmons & Co., 208-212 Lawrence St., Cincinnati, Ohio. Recently, this firm has brought out two floor type machines of essentially the same design, except that they are furnished with a pedestal base. One of these is equipped for belt drive from a countershaft and the other for individual electric motor drive. The clutch and reversing mechanism can be set to run the tap to any desired depth, reverse auto-

Fig. 1. Van Norman Automatic Bore Grinder with Work-head drawn back from Wheel for Gaging

Fig. 2. Van Norman Automatic Bore Grinder with Grinding Wheel in Operation

matically and then stop the spindle automatically. The clutch is of the jaw type, made of steel and hardened. To secure a sensitive drive for light tapping or tapping soft metal, provision is made to adjust the belts to any desired tension. This is accomplished by the lower pulleys being mounted on an eccentric shaft which is revolved by means of a knob on the right-hand side of the column.

The column of this machine is of tubular section, and the bearings are bronze bushed and provided with felt oilers. The lower cone pulley and the tight and loose pulleys run on bronze bearings with oil reservoirs to afford continuous lubrication. The clutch and trip mechanism are made of steel, and all contact points are hardened. The spindle is made of carbon steel and is counterbalanced by an adjustable counterweight. Each machine is furnished with four spindle lead attachments to tap 16, 18, 20 and 24 threads per inch. Extra leads of any desired pitch, including metric pitches, can be furnished as special equipment.

The principal dimensions of this machine are as follows: capacity for drilling to the center of a 12-inch circle; maximum distance from spindle to table, 25 inches; maximum vertical adjustment of spindle, 3¼ inches; maximum vertical adjustment of table, 5 inches; diameter of spindle in sleeve, 13/16 inch; diameter of table, 10 inches; diameter of cone pulley steps, 3½ to 7 inches; width of driving belt, 1½ inch; diameter of tight and loose pulleys, 7 inches; face width of tight and loose pulleys, 1¾ inch; tapping capacity in cast iron, ⅜ inch; drilling capacity in cast iron, ½ inch; and available spindle speeds, 150, 250, 390 and 600 R. P. M.

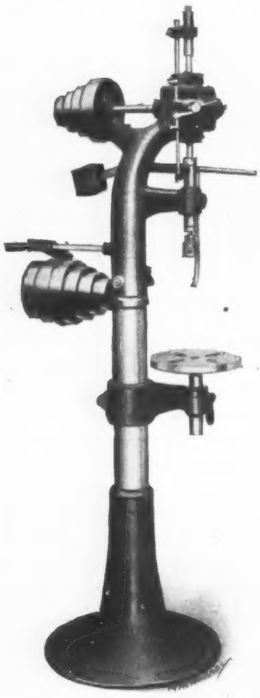


Fig. 1. Simmons Drilling and Tapping Machine with Belt Drive

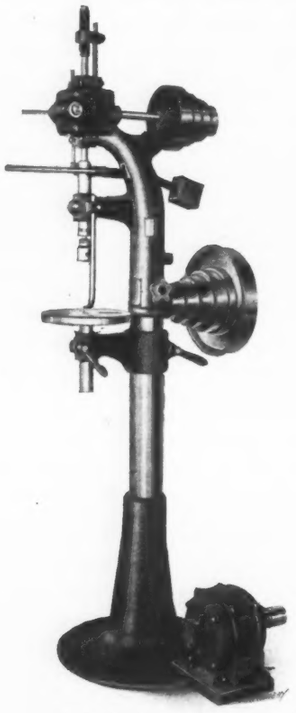
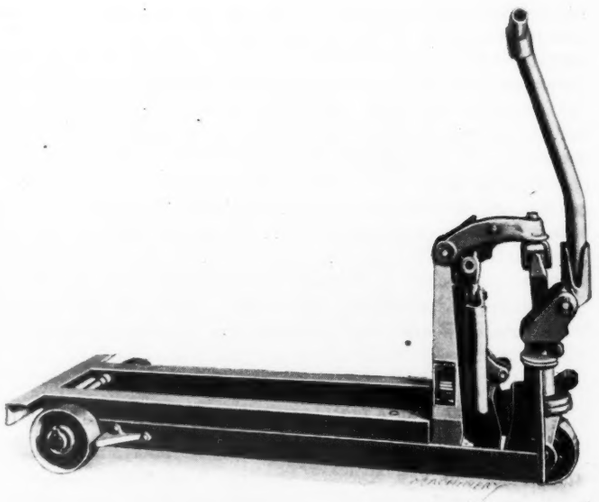


Fig. 2. Simmons Drilling and Tapping Machine with Motor Drive

LEWIS-SHEPARD ELEVATING TRUCK

In the May, 1916, number of MACHINERY a description was published of an elevating truck built in capacities for handling loads from 2500 to 5500 pounds. Trucks comprising this line were heavily constructed to meet the requirements of severe classes of service. Recently, the Lewis-Shepard Co., 48 Binford St., Boston, Mass., has added to its line a Type L "Jacklift" master truck, which is really a lighter model of the trucks previously described in MACHINERY. Their carrying capacity is 2500 pounds, and as they are intended for less severe service, these trucks are more lightly constructed. All the operating features of the heavy-duty type are retained in the Type L trucks. These include obtaining a high lift by moderate pressure on a free-lifting handle, which permits the load to be elevated with the handle of the truck turned to one side, thus enabling elevation to be effected in narrow aisles or other cramped places.



Lewis-Shepard Type L "Jacklift" Elevating Truck

Attention is called to the fact that the only cast or gray iron used in the construction of these trucks is in the wheels; all other parts are made of either malleable iron or crucible steel. Type L trucks are made in six models, three of which have 6-inch wheels and three 10-inch wheels. The lifting ratio is 40 to 1, which permits women and boys to operate the trucks when handling heavy loads. As trucking is one of the departments of labor in which women and boys may be employed to take the place of men who have been drafted for National service, these may properly be called "wartime" trucks.

THE COSTIMETER

The "Costimeter," made by the Costimeter Co., 130 Montcalm E., Detroit, Mich., is an elapsed-time recording device, which stamps directly on a card the elapsed time from one job to another and when used with the "Costimeter" wage chart gives the corresponding wage value. The accurate keeping of time by an operator or workman is reduced to its simplest form, as he has only to place his daily card in the slot on the machine and press the lever upon the completion

Fig. 1. The "Costimeter" for recording Elapsed Time on Manufacturing Operations

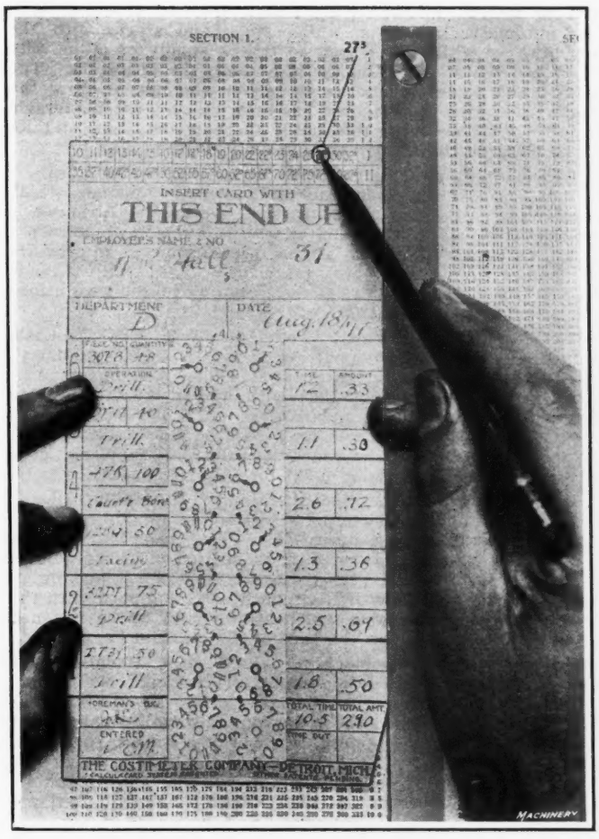


Fig. 2. Use of Record Card from "Costimeter" in calculating Money Equivalent of Elapsed Time

of each job. The lower right-hand corner of the card is cut off at an angle, which operates the safety lever, making it possible to enter the card only in the correct way, face outward and right side up. Upon arriving at the factory in the morning the workman inserts his daily card and presses the lever. Thereafter during the day he inserts the card again after the completion of each job. It is assumed that the foreman or planning department has filled his card out for the various jobs that he is to do throughout the day. His card then is his guide as to which is the next job.

The card and the "Costimeter" wage chart are special for different concerns. At the top of the card is printed the maximum and minimum rate per hour at which the various men in the factory are being paid. The time clerk is enabled to read the time consumed by each job directly off the card, and its equivalent in money is arrived at with little mental effort by placing the card on the "Costimeter" wage chart and reading it directly as illustrated. In Fig. 2 the card of N. P. Hall, No. 31, working in Department D, is shown fully stamped; this indicates that he worked on six different jobs during the day. The dials stamped in the lowest space on the card gives the time in the morning when he started. The next pair above indicates the elapsed time to be one and eight-tenth hours to do the drilling on part DT 39. This is repeated through each of the operations that he completes.

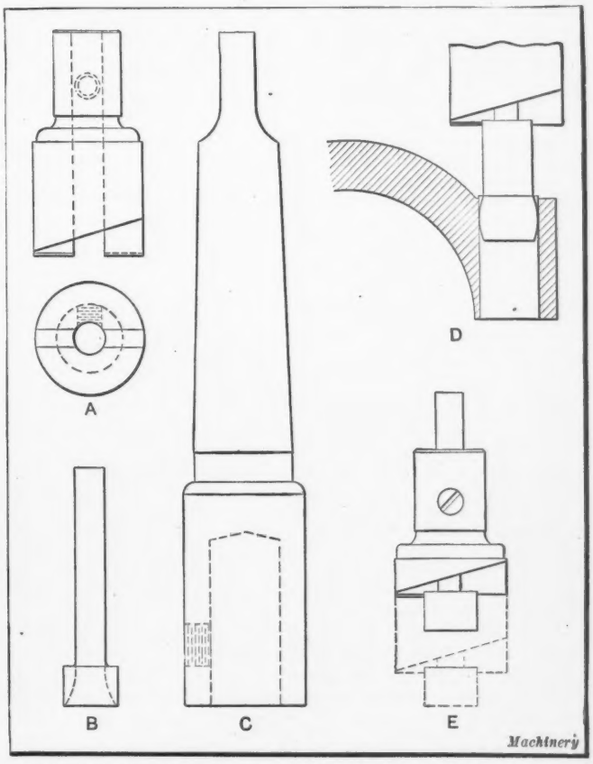
The time clerk places the card on the "Costimeter" wage chart, guiding it by the strip at the right, then glancing at the uppermost stamped dials, he reads "one and two-tenth hours," and enters it in the column marked "Time" on the card. He then slides the card down the chart until the time 1.2 in the list of figures adjacent to the guide strip, is exposed, and then directly above the rate per hour, of this particular man, 22½ cents, he reads "33 cents" and enters it on the card in the right-hand column marked "Amount." Thus we have clearly indicated the elapsed time for any job, and with very little mental effort, its equivalent in money is arrived at with the chart. The operation is repeated by the time clerk in the same way for all the operations and the time is then totaled, amounting to 10½ hours and the money to $2.90.

The operation of the "Costimeter" is simple and consists in placing the card in the slot and pressing one lever. It is furnished as an entirely self-contained device with an eight-day clock or with electrical control. The timing device may be arranged for intervals of any desired frequency, from one minute up, but the customary length of interval is one-tenth hour or six minutes. That is the interval at which the clock was set for making the record card shown in Fig. 2. The machine is constructed along sturdy lines, having a heavy cast-iron frame and base. A device of this kind is likely to be abused by workmen, and it is designed to withstand rough usage.

PRODUCTION SPOT-FACER

Spot-facing operations are often performed where it is desired to secure a local finish on castings, forgings, and similar parts without removing the strong outer skin from other portions of the work. Spot-facing operations are inexpensive to perform, except for the fact that the life of the tools is often quite short. With the view of overcoming trouble of this kind the Production Tool Co. of America, 24 John R. St., Detroit, Mich., has developed a spot-facer that is made with two lips instead of four or six. With this tool it is claimed that the hard surfaces of cast iron, malleable iron, forgings, etc., may be immediately penetrated, and that the tendency of the tool to break has been considerably reduced by the large amount of backing behind each lip. Because of the full buttress form of the lips, head radiates quickly, thus allowing tools of this type to run at relatively higher speeds than could be employed with tools having a greater number of teeth.

Pilots are made up standard with heads ⅜ inch in length. These are well suited for ordinary spot-facing operations, but on many kinds of castings where there are shoulders to cut away before getting down to the base, longer pilots are required to guide the cutter. These are made up in various designs to suit the work on which they are to be used. Pilots used on all heavy work are slotted to fit over the lips of the cutter and thereby release the strain from the shanks. In the accompanying illustration, one of the spot-facing cutters is shown at *A;* a pilot is illustrated at *B;* the holder is shown at *C;* at *D* is shown a spot-facing tool provided with one of the special pilots to which reference has been made; and at *E*



Parts of Two-lipped Spot-facer made by Production Tool Co. of America

is shown a spot-facing tool and pilot assembled. This last illustration shows the original position of the pilot and cutting edges of the tool by dotted lines, while the full lines show how far the tool can be ground away before its period of usefulness is terminated.

NEW MACHINERY AND TOOLS NOTES

Industrial Truck: C. W. Hunt Co., Inc., West New Brighton, N. Y. A Type DF-60 truck which has a 1¼-horsepower motor in each of the front driving wheels. The storage batteries are contained in a separate compartment at the front of the truck and the load is carried on a low platform at the rear.

Cutting-off Machine: Etna Machine Co., Toledo, Ohio. A 3-inch cutting-off machine of the heavy-duty type, which is driven by a two-step cone pulley from a friction countershaft. This pulley has steps 10 and 12 inches in diameter and carries a 5-inch belt so that ample power is provided for handling heavy work.

Portable Lubricant Tank: Gilbert & Barker Mfg. Co., Springfield, Mass. A portable tank outfit for handling cutting oils or lubricants. It has a capacity for 50 gallons of lubricant and is furnished with a quick-acting pump that may be utilized either for delivering clean oil to the machine or collecting the used lubricant and conveying it to the filter.

Disk Grinding Machine: Carter & Bucholz Co., Inc., Syracuse, N. Y. A 15-inch disk grinder which is particularly adapted for use in wood-working shops such as those engaged in pattern-making, cabinet-making and other classes of fine wood working. The machine is suitable for use in making joints, fitting bevels, grinding the draft on patterns and for similar classes of work.

Milling Machine: Standard Engineering Works, Pawtucket, R. I. A hand milling machine equipped with power longitudinal feed and an oil-pump equipment. The power longitudinal feed of the table is secured through a rack and pinion movement that permits a quick return of the table by hand. Four power feeds are provided by means of two two-step feed cone pulleys which are interchangeable.

Airplane Propeller Lathe: Defiance Machine Works, Defiance, Ohio. A No. 613 airplane propeller turning lathe which may also be used for turning other irregular-shaped pieces up to 12 inches in diameter by 10 feet, 4 inches in length. Either right- or left-hand work may be produced from the same model. By a simple adjustment of the tailstock either end of the work or the entire piece can be made larger or smaller than the model.

Worm-hobbing Machine: Moline Tool Co., Moline, Ill. A machine provided with adjustments that enable it to handle work up to 56 inches in length by 13 inches in diameter. A straight hob is employed that is automatically fed into the worm and hobbing of the worm is completed at a single revolution. With this machine worms up to eight pitch may be handled without difficulty. The machine is practically automatic in operation.

Gate Shear: Long & Allstatter Co., Hamilton, Ohio. A large gate shear which has a capacity of 146 inches between the housings and a throat depth of 30 inches. An automatic hold-down is provided for clamping and holding the work while it is being cut, pressure on the hold-down being applied by heavy coil springs. This machine is designed to cut off 12-foot sheets and plates, and is capable of handling work up to 1 inch in thickness.

Portable Crane: Canton Foundry & Machine Co., Canton, Ohio. A portable crane which has a capacity for handling loads up to 4000 pounds. The base of the crane is a steel casting, while the uprights are made of semi-steel and reinforced. The chain is of hand-forged steel and is tested to determine its ability to handle loads exceeding the rated capacity of the crane. Roller bearings are used in the wheel and axle to make the crane easy to operate.

Sensitive Drilling Machine: Waukegan Machine Tool Co., Waukegan, Ill. A 14-inch sensitive drilling machine of the floor type which is adapted for drilling holes up to 9/16 inch in diameter. This machine is provided with two tables, one of which is square and may be swung around the column or tilted to any desired angle; the other table is round, and this table may be removed from the machine in order that a cup-center may be substituted.

Sheet and Plate Cutter: W. J. Savage Co., Inc., Knoxville, Tenn. A machine known as the "Gray No. 3" universal sheet and plate cutter. This machine is especially adapted for cutting shapes instead of handling the work with a hammer and cold-chisel, by drilling or with the use of an oxy-acetylene torch. It is claimed for this machine that cutting is accomplished without springing or buckling the metal and that all edges are left square and true.

Lubricator: Madison Kipp Lubricator Co., Madison, Wis. An automatic lubricator which stops and starts with the machine on which it is used so that a supply of oil is only delivered while the machine is actually in operation. The hand-crank makes it possible to deliver a supply of oil at the start, or in case the machine has been idle for a considerable length of time. With this outfit there is only one oil-tank to be filled on the whole machine.

Lubricant Pump: C. F. Roper & Co., Hopedale, Mass. A pump for circulating lubricants and cutting compounds, which is claimed to be constructed in such a way that priming is unnecessary. It is also said that this pump will deliver a large volume of lubricant at low pressure or at a pressure of from 20 to 60 pounds per square inch. This pump is made in four sizes, with capacities when running at 100 revolutions per minute, of 1, 1.6, 3 and 8 quarts, respectively.

Universal Tool Grinder: Dauber-Kratsch Co., Oshkosh, Wis. A universal grinder adapted for tool, cutter, cylindrical, internal and surface grinding operations. The machine is furnished with a cabinet base with a door at the back to provide for storing tools and fixtures. A shelf is cast at the front of the machine to hold tools used on the machine while in operation. E. L. Essley Machinery Co., 551-557 Washington Blvd., Chicago, Ill., is sales agent for this machine.

Drilling Machine: Moline Machinery Co., Moline, Ill. A 20-inch drilling machine especially adapted for the performance of manufacturing operations. This machine is built with either power or lever feed as desired. The spindle is driven by a worm and gear to insure smoothness and quietness of operation. This drilling machine is equipped with the usual type of swing table which allows work to be fastened on either the table or on the base of the machine.

Drilling and Boring Machine: Pawling & Harnischfeger Co., Milwaukee, Wis. A horizontal drilling and boring machine of somewhat similar design to the No. 12 machine built by this company. There are four mechanical changes of spindle speed and the spindle is made of a high carbon steel forging and bored for No. 6 Morse taper. Spindle thrust due to feeding is carried on a dust-proof ball bearing, the spindle itself running in bronze bearings. Four changes of feed are provided.

Multiple Drill Head: Covington Multiple Drill Co., 2449 W. McMicken Ave., Cincinnati, Ohio. A six-spindle auxiliary drill head in which any number of spindles from two to six may be employed. The spindle units are readily attached or removed to meet the requirements of the work; and each spindle is individually adjustable. When located in the desired position each spindle is rigidly held. Adjustments may be made very quickly, as only one lock-nut is used for securing each spindle in place.

Drilling and Tapping Machine: Barnes Drill Co., 814 Chestnut St., Rockford, Ill. An all-geared 26-inch sliding-head drilling and tapping machine. This machine represents an improvement of a preceding design of the same type built by this company. The present machine is equipped with a new style of self-oiling reverse gear and with an outboard bearing support for the driving pulley. The friction clutches and drive-shaft bearings are continually lubricated by means of a geared pump which delivers lubricant from the reservoir.

Gear-hobbing Machine: Barber-Colman Co., Rockford, Ill. A No. 3 gear-hobbing machine on which the bed and upright are of box section reinforced by ribs which are cast integral. The sub-base is also of box section and contains a tank for the oil or cutting lubricant delivered to the tool. The work-spindle is horizontal. Either a right- or a left-hand hob swivel may be provided, the former accommodating a range of spiral settings from 60 degrees right hand to 90 degrees left hand, while the latter accommodates a range of spiral settings from 60 degrees left hand to 90 degrees right hand.

* * *

The first merchant ship built on the interchangeable plan, or, as it is generally termed, the first "standardized" merchant ship, was put into commission in Great Britain a few months ago. This ship is of 8000 tons dead-weight carrying capacity, and was completed in slightly less than five months. She is the forerunner of a great fleet of sister ships which are now being built. In addition, other standard ships of 7000, 5000 and 3000 tons dead-weight capacity are being built. The waste connected with shipbuilding as it has been carried on in the past, where every ship, as well as the engines and auxiliary machinery used in connection with it, was individually designed, is apparent. It is evident that ships may be built to the same designs just as well as locomotives or automobiles. The war has taught many important lessons in the economies possible in trade and engineering, but few which will prove of greater importance than that in connection with the building of ships in great numbers on the interchangeable plan. The only wonder is that it has not been done before.

MARTELL ALIGNING REAMERS

SYSTEM WHICH COMPENSATES FOR DISTORTION OF CRANK-CASE

BY EDWARD K. HAMMOND [1]

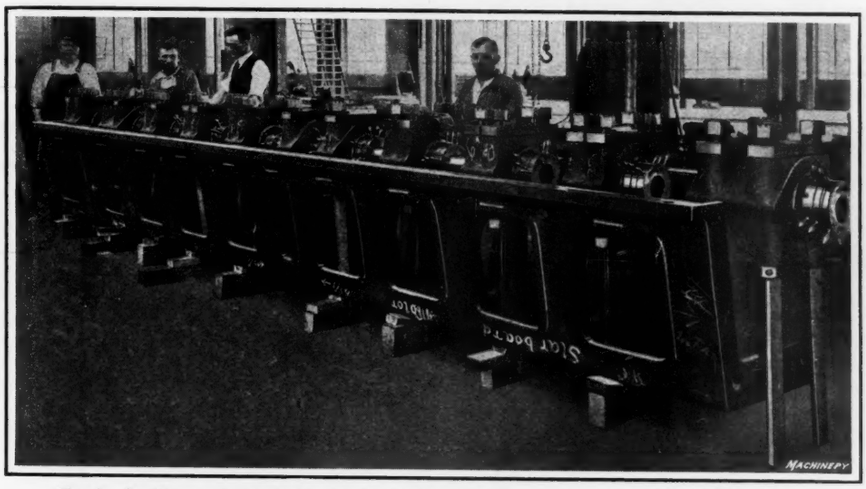


Fig. 1. Crank-case of Diesel Type Engine having Bearings reamed with Martell Aligning Reamer

IN the April, 1914, number of MACHINERY a description was published of the Martell aligning reamer which had just been placed on the market at that time for use in reaming the bearings of automobile crank-cases. Recently the manufacture of these reamers has been taken over by the Taft-Peirce Mfg. Co., Woonsocket, R. I., and tools of the same general type have been developed for handling work far beyond the range of the original Martell reamers. In order to get a clear idea of these tools and their work, the reader must grasp the fact that Martell reamers, as they are now built, are really more than tools adapted for a specific class of machining operations; possibly the term "Martell system of reaming" would be more suitable because when a manufacturer buys Martell reamers he adopts the use of an entirely distinctive system of reaming bearings to insure accurate alignment.

A good idea of the range of work that may be handled with Martell reamers will be obtained from the accompanying illustrations which show reamers engaged in line-reaming the bearings in automobile crank-cases, and in the crank-case of a Diesel engine at the plant of the Winton Engine Works in Cleveland, Ohio, the total length of the latter case being 23 feet.

In the previous article to which reference has been made, attention was called to the fact that with the Martell method of line-reaming, the reamer-bar is supported by a series of adjustable eccentric bushings which are, in turn, supported by the bearings in the work. The reason for adopting this construction is to provide means of offsetting the effect of distortion caused by clamping the crank-case in fixtures used in the preceding operations. If the crank-case bearings are reamed without making allowance for such distortion, accurate results will not be obtained. In preparing for a reaming operation, the reamer-bar with the eccentric bushings in place is set up in the crank-case. Then the eccentric bushings are adjusted so that the reamer-bar is in accurate alignment. (Before starting to ream the bearings in the crank-case, the bar is withdrawn from the end bushings alternately, and if it can be pushed back without interference, it shows that all the bushings are in accurate alignment.) Otherwise the eccentric bushings must be adjusted until this test can be made with satisfactory results. Experience gained with the Martell reamer has shown that it not only produces more accurate alignment in the bearings, but that it is also the means of considerably reducing the time required for performing hand operations, and in some instances entirely eliminates them.

Referring to Fig. 1, it will be seen that the crank-case illustrated has eleven bearings which receive the crankshaft shown in Fig. 2, that has journals 8 inches in diameter. The total length of this case is 23 feet and to avoid the obvious disadvantages of making a reamer-bar the entire length of the case, a bar 10 feet long is used, the idea being that if the alignment of four bearings were accurately secured, the fifth bearing could easily be located from the original four; and if the fifth could be located accurately, the sixth and all succeeding bearings could be treated in the same manner. This supposition was borne out in practice, and it was found on the first attempt that the alignment was materially better and that a great saving in time had been secured.

Fig. 5 shows the construction of the centering bushing. The cone *A* is made of pack-hardened machinery steel, and is provided with a fine-pitch thread on the tapered surfaces, which allows it to be screwed securely into the soft metal of the bearings to be reamed. At *B* and *C* are shown, respectively, the inner and outer eccentric bushings. The inner eccentric *B* is bored and ground to a neat running fit for the reamer-bar. Outer eccentric *C* is bored and ground to a like fit on the eccentric portion of bushing *B*. As the eccentricity of these two bushings is the same, it is at once seen that there will be a certain point at which the hole in the inner bushing is exactly concentric with the outer diameter of the outer bushing. In other words, the rotation of the inner bushing in relation to the outer bushing determines the amount of eccentricity or distance off center that the bore of the inner bushing shall assume in relation to the outer diameter of the other bushing. The rotation of the two bushings within the conical sleeve determines at what point or in what direction the center line of the bar shall lie. Lock-screws are provided on all these members to permanently maintain the alignment.

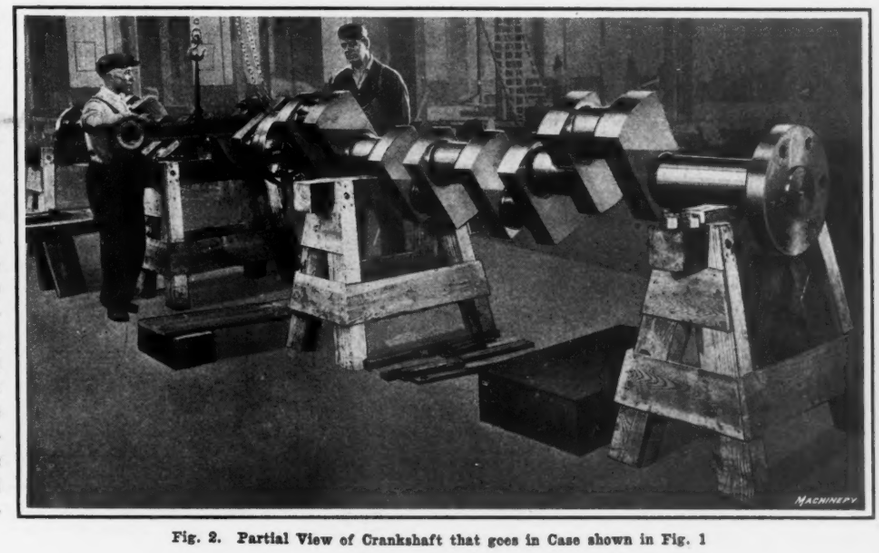


Fig. 2. Partial View of Crankshaft that goes in Case shown in Fig. 1

[1] Associate Editor of MACHINERY

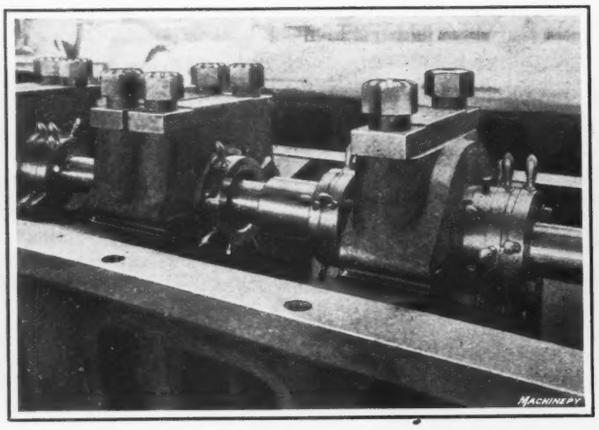


Fig. 3. Close View of Reamer-bar supported in its Centering Bearings

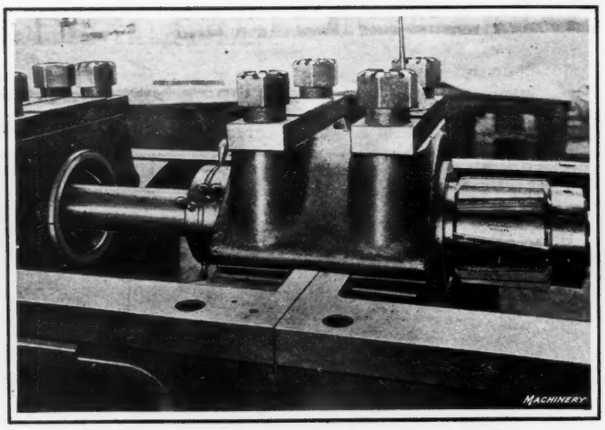


Fig. 4. Close View of Centering Bearing and Reamer Ready for Operation

At the top of Fig. 5 is shown the construction of the reamer, which is of the shell type and has eight adjustable blades. As will be noticed these blades are set in at a slight angle to the axis of the reamer-head—six of them having a left-hand angle and two a right-hand angle. Adjustment is secured by means of the adjusting nuts *D* and *E* at each end, which are ground on the surfaces adjacent to the blades to the same angle as the ends of the blades. The expanding members consist of pack-hardened and ground wedges which are held in the bottom of the slots by means of bosses, formed integral with the wedge. It is claimed that very close variations in size can be secured by means of this type of adjustment. The reamer-head is driven by means of screw pins on opposite sides of the body which engage the recesses spaced at intervals in the reamer-bar. Provision was made on this bar for power drive as well as by hand. It was found, however, that it was an easy matter to ream the bearings without the use of power. In view of the great quantity of engines of this type and of various sizes now under construction it would seem that there is a wide field of usefulness for this tool in marine work.

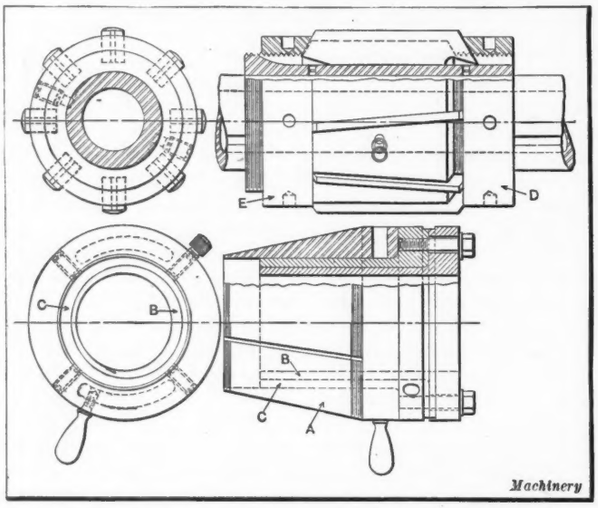


Fig. 5. Top View—Type of Reamer used; Bottom View—Adjustable Bearing for Reamer-bar that provides Compensation for Distortion of Work

Compensating Line-reaming Fixture

A careful study of existing practice in line-reaming the bearings of automobile crank-cases disclosed these facts: The average manufacturer of motors is very particular about the balance of crankshafts; practically all of them are using the Norton static balancing machine, and more recently many are also using the Akimoff dynamic balancing system. This great care is exercised in an effort to reduce, in so far as possible, the phenomenon known as the "whip" of a crankshaft. The whip of the crankshaft makes its presence felt by a decided vibration of the motor, which in most cases is recurrent with some particular speed or multiple of that speed; for instance, one vibrating period will occur at 650 R.P.M., another at 1300 R.P.M., and still another at 2600 R.P.M. Many efforts have been made to overcome this trouble, and at present the most approved method is to counterbalance the crankshaft webs individually. This has been carried to such an extent in one popular motor that the crankshaft and flywheel weigh about 360 pounds. The performances credited to this motor indicate that this method is effective.

Fig. 6. Setting up Centering Bearings in an Automobile Engine Crank-case

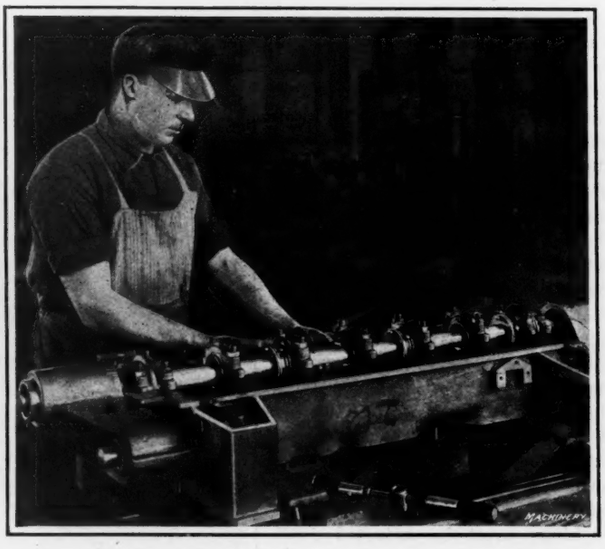


Fig. 7. Adjusting Eccentric Bushings in Bearings to secure Alignment

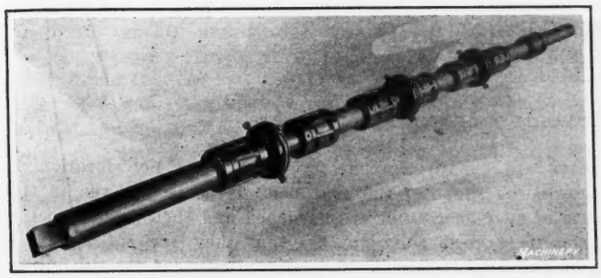


Fig. 8. Small Reamer-bar used in Automobile Crank-cases, shown completely assembled

It is fairly safe to assume that the art of balancing crankshafts is developed to a point of great accuracy. Let us now look at the bearings that carry this finely balanced shaft and see if the methods of alignment are fine enough to form a true path in which this shaft is to revolve. Assume that the Martell line-reamer is used to ream the bearings in an absolutely straight line. The practice in all motor factories, when reaming bearings, is to turn the crank-case upside down, for the sake of accessibility, and support it in what is known as a "motor jack." A motor jack is simply a frame of wood or metal, and in most cases the crank-case rests on it either on the milled surface that receives the cylinders or on the motor supporting arms. Having reamed the bearings in the crank-case to an accurate size and finish, the crank-shaft is assembled and the connecting-rods and pistons are attached; the motor is then turned right side up, and the cylinders, starting motor, carburetor, generator, transmission and other parts are attached. It is an accepted fact that weight applied to a beam will deflect that beam, no matter how light the weight nor how heavy the beam. So in this case, the crank-case is usually made of an aluminum alloy and strongly webbed, but the addition of the very considerable weight embodied in the parts that are attached after the reaming operation has been performed, cannot help but deflect the case, and therefore cause disalignment of the carefully reamed bearings.

In an effort to get something tangible with which to work, a test was made on a six-cylinder motor crank-case. The large case used in this test has seven bearings and the cylinders are cast in pairs. In conducting this test the crank-case was turned bottom side up as usual; the Martell reamer-bar was supported by the locating fixtures, and three Martell supporting bushings were attached in the usual manner. After the bar was correctly lined up, two of the supporting bushings were removed, leaving the bar supported by the locating fixture at each end and one bushing in the middle bearing. By carefully measuring the distance from the reamer-bar to the bore of the cap, using a small pair of inside calipers and a micrometer, the position of the bar when truly aligned was determined. The eccentric bushings were carefully marked as to position and then removed, and the distance from the reamer-bar to the bore of the cap was once more calipered. The difference between these distances proved to be 0.001 inch and showed the amount of natural sag in the bar. Replacing the eccentric bushings in their original positions, the crank-case was reversed and placed on a running-in jack, on which it was supported by the lugs that are used as supports when the motor is assembled in the chassis. The cylinders were next bolted on, all electrical apparatus was attached, the crankshaft, connecting-rods and pistons were placed on top of the cylinders in approximately their normal positions relative to the horizontal plane, and the flywheel was suspended opposite its normal position. A careful measurement of the distance between the reamer-bar and the bearing cap at the point used in making the former measurement showed that the deflection was 0.007 inch direct reading, and adding to this figure the deflection of the bar of 0.001 inch gives a total deflection of 0.008 inch. This same test was applied to another crank-case which showed a deflection of 0.0025 to 0.003 inch. This case was shorter and deeper, the oil-pan was very stiff and ribbed on the outside in a fore and aft direction, and the cylinders were cast *en bloc* and there are two blocks.

Fig. 9. Performance of Line-reaming Operation on Automobile Engine Crank-case

To thoroughly understand the method of making up for the differences due to the reversal and loading of the crank-case after reaming, it must be understood that the crank-case is left bottom side up as before, while reaming; but the same load is artificially imposed on the case, and in the same direction that it normally sustains when mounted in the chassis. Fig. 10 shows what for lack of a better term is called a "compensating reaming fixture." Supported in this fixture is shown a V-type crank-case. Straps *A* are provided at each end of the fixture, which come in contact with the lugs of the crank-case and resist the upward pressure exerted by the weight through action on lever *B* that swings on fulcrum *C* and exerts pressure through equalizers *D* and *E*. These equalizing bars are provided with various holes to allow for any needed adjustment to secure the proper alignment. The pressure is applied to the crank-case through yoke *F* and pads *G*.

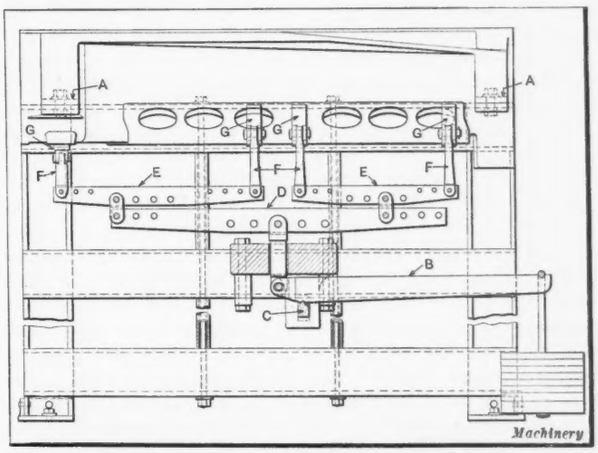


Fig. 10. Compensating Fixture used to enable Reaming Operation to be performed under Same Load that Crank-case carries in Assembled Motor

This fixture must be calibrated for each type of motor that is reamed, and the calibration is determined as follows: The crank-case fully loaded with all equipment, but with the crankshaft bearings open, is placed in a chassis. The Martell reamer-bar is then carefully lined up in the crankshaft bearings, using several supporting bushings and making sure that the bar will slide both ways and enter either end bushing without touching the sides of the holes. Remove all parts from the crank-case and place it in the reaming fixture, and then shift the weights and equalizing bar centers until the bar slides back and forth as before. Having calibrated the fixture in this way for one type or model of crank-case, all other crank-cases of the same model can be reamed in the fixture without changing the weights or equalizers, as any differences in crank-cases due to molding would be automatically cared for. Data are not available to show that the use of this device will eliminate all crankshaft whip, but it seems reasonable to believe that a variation of several thousandths inch in the alignment of the bearings, with a speed of 1000, 2000 or 3000 R.P.M. would cause trouble, and if it is possible to straighten the path of the crankshaft, some advantage will be gained.

THE INSPECTION OF GEARS[1][2]

TESTING SPUR, BEVEL, HELICAL AND WORM GEARS—HARDNESS TESTS

THE inspection of gears requires as much attention as the making. If the requirements are not severe, the inspection need not be; but if the gears must work at high speeds and under severe stresses with quietness an essential factor, the inspection must be strict. In other words, the more exacting the gear requirements, the more exacting must be the inspection, not only the final examination, but also the tests between the various operations, to make sure that the gear is not spoiled, and that other operations will not be performed on a gear that will not pass the final inspection. These inspections are also necessary to insure that one department does not do poor work, with the expectation that some other department will correct the error. The methods given here apply principally to gears of the smaller sizes and are those used by the Brown & Sharpe Mfg. Co.

It is the practice of this company in the case of all gears made to a customer's specifications to first inspect the gear blank. Then after cutting the teeth, the gear is inspected for the running or rolling qualities of the teeth on a hand testing machine, unless the specifications state that the gear must run quietly at some given speed. In this case, the gear is mounted on a power-testing or speeding machine, and run as nearly as possible at the speed at which it will run in practice. When the gears are to be used in the company's machine tools, some of the intermediate inspections, such as the blank inspection, are not necessary. It has been found that any error in the blank that will affect the running of the machine will be discovered at some time before the final inspection of the machine, which is always made under the belt.

It is also the practice of the Brown & Sharpe Mfg. Co. to mark the drawings of gears that will have a speed of over 400 feet per minute with a note to that effect, the note stating simply "Speed 600 feet," or whatever the speed may be. This shows the man responsible for the cutting that he must take the necessary precautions to cut quiet gears and also shows the inspector that he should inspect the gears carefully. It has been found that this practice eliminates misunderstandings as how carefully the gears should be cut and inspected, and has considerable influence on the time consumed in the cutting operation and the inspection.

Testing Spur Gears

The method of testing the average spur gears used by the Brown & Sharpe Mfg. Co. is the usual one of mounting the gears on studs at the correct center distance. The most satisfactory way, in most cases, is to have adjustable studs where one fixture or machine will take care of a wide range of center distances; there are several such machines on the market. Where gears are too large for such a machine, a gear-tooth caliper set to chordal figures is a satisfactory way to get the pitch diameter correct. This test consists of calipering the teeth for size and variation; although very large gears may be cut to the correct depth, as the center distance is usually adjustable. In testing the gears used on the company's variable spindle speed and variable feed cases, stud plates are used, where the various gears can be tested at the correct center distance and with each gear it may have to run with. But for general work, standard spur-gear testing machines are used with what is called a spur-gear indicating attachment, which has been found useful for testing the run-out and also the rolling qualities of the gears. In using this attachment, the gears are pressed together by springs while a dial indicator presses against a square stud in the slide, so that any tendency of the gears or slide to move away from the mating gear, due either to run-out or poorly shaped teeth is shown on the dial. It has been found that when the indicator pointer vibrates from tooth to tooth not over 0.001 inch, the gears are usually satisfactory; and when no vibration is shown, the shape of the gear teeth is perfect. Even in the case of spur gears that are hardened and then ground in the hole, it is good policy to see that they are cut true, for then the inspectors need not make allowances for run-out in testing; besides, this practice keeps up the quality, or tone, of the gear-cutting in general.

Transmissions are run off in a test stand of some kind and tested with a light load or without any load. Usually, if a pair of gears or a transmission running dry does not rattle, the gears will run quietly under load.

Testing the Run-out

A test used in connection with the grinding of the holes in spur gears for the so-called "run-out" in gears is that known as the ball test. The apparatus consists of a pair of centers under a spring-plunger block. A ball on the end of the plunger fits between the teeth of the gears at about the pitch line, and the point of a dial indicator rests on the top of the plunger. The plunger block, which is fitted with quite a stiff spring, is used between the indicator and the work to rotate the gear into position while the indicator shows the "run-out," or variation in the pitch line. The final run-out in the gear is tested with this apparatus. The number of spaces the plunger is set into depends on the requirements of the gear.

A gear with a run-out sound, usually causes trouble, no matter how nicely the teeth may be cut or shaped. There can be, and often is, cause for a difference of opinion as to the degree of quietness of a pair of gears, but there is not much chance of this in the case of a run-out, for anyone can detect a run-out sound, and for this reason it is very objectionable.

In the case of cones built up of a number of gears keyed and pressed on a shaft, the inspection for run-out should be made after assembling. Index change-gears and lead change-gears must be cut true, as they are usually meshed closely, and a bad run-out in an index gear might prevent the machine indexing properly.

Inspection of Bevel Gears

The bevel gears that require the closest inspection are probably the driving bevel gear and pinion for automobiles. It is necessary to hold these closely to figures in the blank, and an effort is made to cut them dead true. It is not good practice to let gears of this type with run-out in the teeth go to the fire, expecting that the grinding department will overcome it. An out-of-round sound is usually fatal to these gears.

After the teeth are cut in driving bevel gears, the soft gears are tested in the hand testing machine with a hardened master gear, to determine the bearing between the teeth and the feel of the gears. They are then tested on a speeding machine with the same master gear and under some load. After they have been hardened and the holes and webs have been ground for the final inspection, they are tested in pairs as they will be shipped, but not in the particular order in which they will be used on the axle. The procedure is as follows: A gear is mounted and several (four or five) pinions are run with it; then the gear is removed and four or five gears are run with these pinions, so that every gear and pinion sent out has been run or tested with one or more pinions or gears. In this way the gears are kept interchangeable as nearly as possible. It can be seen that if the final product were tested with the master gears only, should an error appear in the cutting, the master gears might lend themselves very slowly perhaps to this error and fail to show it; but when the product is run together, an error that might not show with the master gears will appear, and it may be such that the gears are not usable. The customer is never interested in how well the gears furnished run with the master gears, but how well they run together and at the same time interchange with the gears previously sent him. The company has also adopted

[1] Paper by Benjamin F. Waterman, read before the American Gear Manufacturers' Association's convention in Chicago, Ill., September 14.

[2] See also "Gaging and Inspecting Gears," in MACHINERY, April, 1917.

this method on gears for its machine tools, and repairs can be made quickly and surely, because the inspectors have tested the gears just as they will run together, previous to their going into stock.

In testing driving bevel gears for the amount of run-out, the ball-testing fixture is used. This fixture makes it possible to clamp the gears down to a rigid spindle and, with the spring-plunger block, to bring the space of the gear centrally under the plunger; the dial indicator will then indicate the run-out. The bevel pinion can be tested in this way for run-out by adjusting the plunger block to the suitable angle and setting the pinion on a stud. These run-out tests are not made in the final inspection unless the gears have shown a run-out in the running test. In this case, an effort is made to find the exact amount of the run-out and the possible remedy.

The average bevel gears are tested by hand on a bevel-gear testing machine. Care is taken to have a full length bearing along the teeth; if the bearing falls short of being full, as it may do owing to the need of some working limit, it is expected that it will bear heaviest on the inside or small end, as the bearing will pull in or extend full length with the least wear and the spring of the bearings or shafts.

Testing Spiral Gears, Helical Gears, and Worm-gears

In testing spiral gears that run at right angles, about the only thing that can be done is to see that the center distance is correct, with some backlash for oil space, and that the surfaces of the teeth are as smooth as possible. Any test of spiral gears other than under actual working conditions is rather unsatisfactory, for they are unreliable to use except where the pressures are light.

This is also true of helical spur gears, as they are made only for high speed, although it may be possible to develop a running test at some speed that will serve to show the defects in the gears, if there are any. The Brown & Sharpe Mfg. Co. has decided that there is no test that can be satisfactorily used in testing helical timing gears by anyone else but the user, and for this reason it has hesitated to cut these gears, as it feels that the user or motor manufacturer should assume the responsibility of cutting them.

Worm-gears, as they are being used today, require closer inspection than ever before, as more is expected of them. It was only a short time ago that the worm-gear had a poor reputation for serviceability, but since the advent of the worm-driven motor truck this gear has taken a new lease of life. So, now that more is expected of the worm-gear, greater care must be taken in the inspection.

With the difficulties that arise with the average worm-gear cutting equipment, it is not enough to know that the hob is marked correctly or that the centers of the spindles of the hobbing machine are the correct distance apart when the gear is finish-cut. The worm and wheel should be mounted at the correct center distance and in proper alignment to be sure that the bearing between the worm threads and the wheel teeth is correct, a point that increases in importance as the service to which the gears are to be put increases in severity. On large gears, where a testing machine would be out of the question, the worm can be laid in the wheel and measurements taken from a straightedge (laid across the rim of the wheel) to a bar in the hole in the worm or to the worm-shaft. If the measurements taken on one side or end of the worm differ from those taken on the other, it is evident that the shafts are not at right angles with each other. If these gears are mounted in a gear-case in which the shaft bearings have been bored square, the bearing between the teeth will be a cross-corner one, and the amount of this bearing will depend on what the wheels have to do. When the pressures carried by the teeth of worm-gears are taken into consideration, it is evident that the bearing should be as full, or broad, as possible.

When testing the average small worm-gear, this company uses its bevel-gear testing machine, which is also a worm- and spiral-gear testing machine. But for automobile-truck driving gears, it has fitted up a special machine, where the gears can be run under some pressure. This machine is fitted with a scale and a vernier for reading the center distance.

Hardening Inspection

Probably no inspection operation depends more for its success on the very operation it professes to inspect than the hardening inspection. When inspecting the machine operations performed on a gear, the mechanical errors can be determined with the measuring tools, and it is possible to feel and hear how smoothly and quietly the gears run. It is therefore possible to pass judgment on them without considering what equipment or methods were used in producing the results obtained. When it comes to testing the gear for the quality of its hardness, however, we find we cannot do more than give it a superficial test, which may mean a great deal if we are sure the hardening was done properly, but which means very little if the hardening was done improperly.

Assuming that the proper treatment for a given gear is known, it is essential that the men in charge of the hardening operation should supervise it closely so that no deviation from the best treatments is made, for the slightest lack of attention produces unsatisfactory or weakened gears which cannot be discovered until they break in service. This satisfactory treatment must be determined by measured breaking tests of gears and an examination of the fracture, to determine not only the depth of case but the condition of the grain of both the core and the case. From a gear having undergone this test, the desired scleroscope and Brinell readings may be found.

This breaking test cannot be carried on indiscriminately, of course, owing to the expense of making test gears, but it is so good a check on the work that it should be done as often as possible or as often as the job will warrant. If gears that have been spoiled are hardened with the good gears and then the teeth are broken, either under a drop or with a hammer, and the fracture is examined, the quality of the hardening may be checked under the best conditions with the least expense.

As a rule, the Brown & Sharpe Mfg. Co. also tests every hardened gear with a ball-peen hammer for depth of case and with a file for hardness. The scleroscope and Brinell machines are used as auxiliaries, except where a customer may demand a given reading from either machine when it becomes the decisive test.

Besides these tests for hardness, on driving bevel gears, this company tests for flatness on a surface plate and for any disturbance of the web in the direction of the axis of the gear. This test is a hardening-room test, for if it is found that gears are becoming distorted in hardening, it is necessary to change the hardening fixtures.

At times, after all these tests have been made, and probably after any other possible test, there is always the question as to whether the gears will run satisfactorily under actual service conditions. As a result, it is sometimes advisable to have gears tested under these conditions before proceeding at full speed to manufacture. When the gears are satisfactory, it is a good plan to have a pair or set that has been tested out in actual service to hold as master gears, with which the future product can be compared. In closing, it should be said that the amount or severity of the inspection of any gear depends entirely on the purpose for which it is used, although at all times that quality which represents your product should be maintained.

* * *

The following note was published in a contemporary in the year of our Lord 1916, although it reads as if clipped from a journal of 1876:

> It largely facilitates the execution of work if the actual worker has a scale drawing to refer to, on which the dimensions are clearly marked. Such drawings may very well be tracings on paper, done in waterproof ink, the finished tracings being fastened to a board with Stickphast paste, Gloy, or other cheap and efficient and hard-drying mountant, as usually rough usage has to be provided for. Tracings can be produced at a cheap rate, where only essential outlines are given, and neither shading nor color is used, the outlines only being necessary in the workshop. Blueprints may be mounted in the same way, where they are fixed sufficiently to bear light exposure, and possibly some amount of dampness, but these too often "run," and, as a rule, do not stand well.

TOOL SYSTEM THAT PREVENTS TOOL SHORTAGES

BY D. M. PERRILL [1]

One effect of the increasing difficulty experienced in securing tools, tool steel, or toolmakers has been a greater interest in the tool-crib. The development of the system of which this article treats is not a war-time measure, but present conditions make it a most timely subject. Realizing the vital need of ascertaining their tool needs well in advance so that proper time might be given to secure or make the tools, the Lodge & Shipley Machine Tool Co., Cincinnati, Ohio, has developed a new tool record system. Until recently this company used the check system, each man having a supply of brass checks or tags, for each of which he deposited five cents. This amount was returned to him when he turned in the checks, either on leaving or when he was transferred to some work that did not require them. Hooks were placed on the tool-crib shelves immediately beneath each tool position. When a man obtained a tool, he turned in one of the brass checks, which was hung on this hook until he returned the tool. The check was then given back to him. The faults encountered in this system were:

1. There was no record kept of the purpose for which the tools were used, and it was impossible to tell what tools had been used in producing a given piece. It was therefore impossible to check the tools called for by the routing department with those actually used in manufacture. These differences might be due to some particular hobby of the workman which it would be well to correct, or they might represent an omission of the routing department, which the workman took care of on his own initiative without referring the matter to the proper parties. In the latter case, if the tools used for some run were checked up from the routing department's information, the necessary tool might be missing without being noticed. Then again, all of the type of machines called for by the routing department might have been busy and the foreman might have done the work on some other machine without any record being made of it.

2. Since no record was kept of the purpose for which the tool was used, there was no way to tell where excessive breakage or wear occurred in the tool during the manufacture of some particular part, unless the workman or his foreman reported it. This made it difficult to find what tools needed strengthening or redesigning.

3. There was no way of telling just what tools a man had except by looking through the entire tool-room and noting the checks on every hook, and then nothing could be told of how or for what he was using them. For this reason, too, in looking through the tool-crib for tools soon to be needed, no estimate could be made concerning the possibility of using tools that were checked out of the tool-crib, since it was impossible to ascertain for how long these would be used.

[1]Address: 346 Probasco Ave., Cincinnati, Ohio

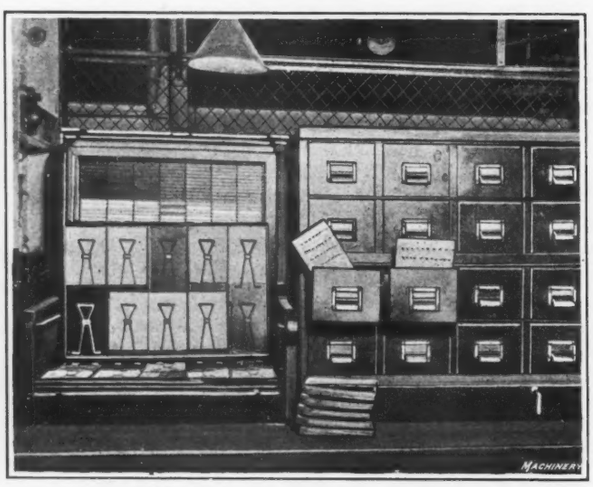


Fig. 1. Files used in keeping Temporary Record of Tools while out of Tool-crib and Permanent Record of how Tools are used

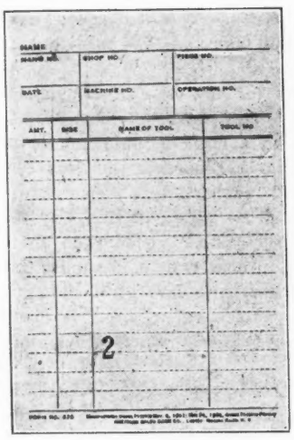


Fig. 2. Form used for both Temporary and Permanent Tool Records

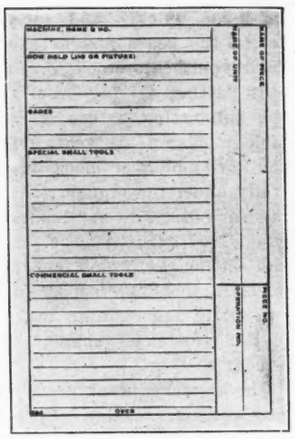


Fig. 3. Operation Card, giving Details of Each Step in machining Work

4. This also made it practically impossible to check up the tools at the workman's bench to see if they corresponded to the ones called for by his checks. This was necessary whenever a man was leaving, and the increasing labor turn-over made this point of steadily greater importance.

5. The men could secure tools, such as micrometers worth several dollars, by turning in a brass check having a value of five cents. On leaving, a man could hold out the tool and lose only five cents, since there was no positive record to prove that the check had not been misplaced on the micrometer hook when the workman received some other tool.

A triplicate form system was installed to do away with these troubles. It gives a complete record of the tools required for the manufacture of any given piece, so that it is possible to tell exactly what tools will be required for a given set of machines as soon as the pieces required are known. Three records are used; the original (pink sheet), the first carbon (yellow sheet), and the record card made as the second carbon (Manila board). All three use the form shown in Fig. 2; one is given to the man securing the tool, the other two are filed. One of the files is temporary and is only used to show the tools that are outside the tool-crib, who has them, and what they are being used for. The file used for this record is one that has been especially developed for use in keeping accounts in groceries and retail stores, and is admirably adapted for keeping tool accounts.

The file will be seen to the left in Fig. 1. Steel clips hold the slips in place. On each of these clips is a number under which the slip is filed. An index, a part of which can be seen above the boards holding the clips, gives the men's names and their numbers. The other record is filed permanently in a standard metal card file, shown to the right in Fig. 1. Some of the triplicate record books can be seen in front of the files. When a tool is requested, these forms are filled out and may be used in either of two ways, depending on the conditions. When there are several duplicates of the kind of tool asked for, or when there is no possibility of the tool being needed by another workman, the original copy (pink) is given to the man to whom the tool is issued, the first carbon copy (yellow) is put in the register, and the record carbon copy (Manila card) is put on the permanent files for setting up and checking up the operation card, Fig. 3.

When there are only a few of the tools on hand and there is a possibility of the supply being exhausted, the original copy is given to the workman as before, the first carbon copy is put in the tool crib in the space where the tool was, and the record card is put in the register. The object of this is to make it easy to check up the tools that are out in case there is a shortage. In this way it is easy to call in the tools that are not in actual use, or to ascertain whether the workman will be finished with them by the time they are required.

When the tool is returned the workman brings back the original copy with it; this and the first carbon copy are destroyed. If there has been no possibility of tool shortage and the record carbon copy is in the permanent files, it is simply

left there. However, if the record carbon copy was placed in the register while the first carbon copy was retained in the tool's place in the tool-crib pending the return of the tool, the first carbon is destroyed as previously and the record carbon copy is now transferred to the permanent files. In order that the record carbon copies may be of maximum use in checking up and setting up the operation cards, care is taken to fill the spaces calling for the man's number, piece number, date, machine number, and operation number as carefully as possible.

To see if the tools are lost or broken, the register is gone through once each week, and all slips two weeks or older are checked up. The broken tools are noted on the carbon record copy so that the fact can be seen in checking up the operation card. Every two weeks the tools that the men have are checked against the slips. In this way it is possible to gather up all the tools that are on the various benches and to find those for which the men have no slips. The slips used in making this check are the originals which were given to the workman when he obtained his tools, and which he is required to keep and return with them. This matter of checking up the tools on the benches is of particular value in shops operating both a day and a night shift, as in this particular instance. By consulting the record of the man who is off, it avoids any chance of a tool being left on one man's bench under the impression that the other man is using it.

The greatest value of this system is the prevention of tool shortages. In the Lodge & Shipley plant all machines are built in lots to secure the greatest accuracy and the maximum production. The product is assembled from interchangeable units. The number of units required are laid out and divided into the various assemblies, sub-assemblies, and finally the individual pieces. In this shop, this takes place about three months before the machines are required. At this time the tool-room foreman and the tool clerk go over the pieces required, checking them against both the actual record of the tools previously required and the operation card. Any shortages are noted and taken care of immediately, so that the tools are in stock long before they are actually required for use in manufacturing.

* * *

SHADOW ON DR. DIESEL'S DEATH REMOVED

In justice to Dr. Diesel, the engineer who invented and so remarkably developed the engine that bears his name, and whose untimely death in October, 1913, while crossing from Antwerp to Harwich, England, on the steamer *Dresden*, was at the time explained as suicide due to despondency over the condition of his business, it should be mentioned that later information indicates that there could have been no such cause for his suicide. Articles now published in America by Axel Bjornsen, a Scandinavian who served for many years in the German submarine and torpedo boat service, indicate that Dr. Diesel's death was due not to suicide but to murder. A peculiar coincidence may be mentioned in this connection. If it is true that Dr. Diesel met his death in the manner indicated by Mr. Bjornsen, he is the second of the great inventors in the internal combustion engine field who has thus met his death. The Frenchman Philippe Lebon, one of the earliest workers on engines of this kind, was murdered in 1804 in a similar manner, the murderer never having been apprehended. It is believed that if Lebon had lived to develop his invention further, the internal combustion engine might have been developed to a commercial stage earlier than the steam engine, and there might have been a complete reversal in the development of steam and internal combustion engines in the first half of the nineteenth century.

* * *

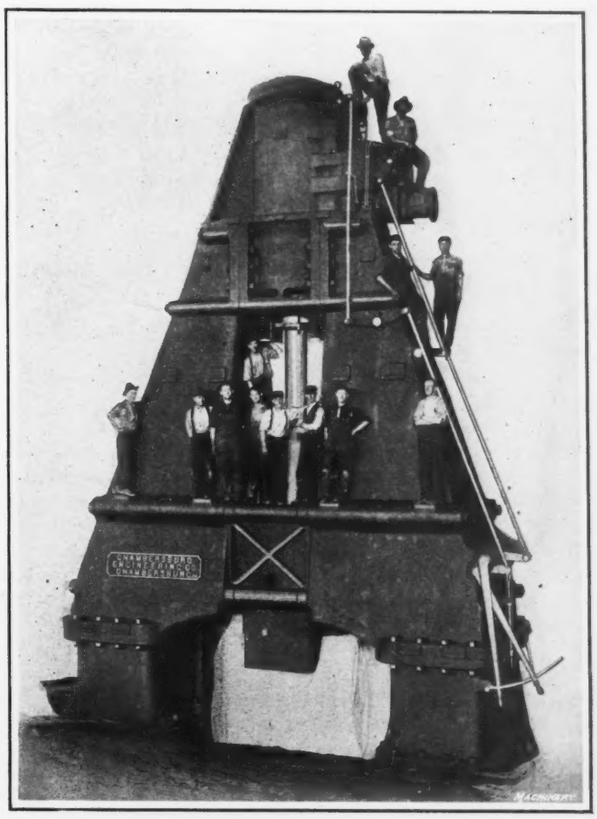
CORRECTION

In the article "Strength of Condenser Tube Plate," on page 65 of the September number of MACHINERY, the line just above Fig. 2 should read: $A_n = A_g - A_o = 0.524 - 0.221 = 0.303$ square inch. This was merely a typographical error and does not affect the rest of the problem.

HUGE CHAMBERSBURG DOUBLE-ACTING STEAM FORGING HAMMER

The illustration shows a forty-ton, double-frame, double-acting steam forging hammer recently built by the Chambersburg Engineering Co., Chambersburg, Pa., and shipped to the Washington Steel & Ordnance Co., Washington, D. C. It is said to be the largest double-acting steam forging hammer ever produced in the United States. It required fourteen railroad cars to ship the hammer in sections.

The cylinder is 40 inches diameter and 96 inches stroke. The main steam pipe is 10 inches in diameter, the exhaust pipe 14 inches, and the diameter of the piston-rod is 15 inches. The ram proper is 51 inches wide, 66 inches thick from front to back, and 72 inches high. It is dovetailed to hold a steel die 72 inches long, front to back, 41 inches wide, and 28 inches high. The approximate weight of the die is 10 tons, and the total weight of the falling parts is approximately 80,000 pounds. The main cylinder is lined with cast-iron bushings of special mixture, and the cylinder proper is mounted between



Chambersburg Forty-ton Double-acting Steam Forging Hammer

the two main frames in machined fits and is securely bolted with body bound bolts, the frames being shrunk together with four large rods or bolts, making the upper works of the hammer one rigid piece. The superstructure is mounted on four massive pedestals and is fitted to them with large steel body bound bolts. Underneath the four pedestals and securely fastened to them are the two heavy base-plates, which are spaced apart with cast-iron distance pieces and shrunk together with two heavy steel tie-bars.

The hammer was built for use with steam pressure of from 100 to 150 pounds per square inch, and with full steam pressure is capable of delivering a blow of 8000 tons. The anvil, steel anvil cap and steel die weigh 350 tons. The total weight of the hammer is 600 tons. The hammer was built to drawings; jigs and fixtures and all parts were machined accurately and independent of assembly. It was erected in the plant, taken down, and re-erected in the plant of the Washington Steel & Ordnance Co., and put in operation within one week.

* * *

A machine gun in operation uses up a bale of cotton in three minutes.

PRACTICAL WARTIME SHELL MAKING[1]

So many foolish statements have been made in regard to the manufacture of munitions and the possibility of automobile factories, implement works or other equally ill-adapted shops being turned, upon very short notice, into shell factories that it seems well to consider of how little value for the manufacture of munitions is the equipment of the average shop. Outside of the already existing munitions plants, the equipment that manufacturers brought to the business of shell making consisted mostly of their money and credit and the nucleus of an organization. The machinery and tools were more than 90 per cent new, and the greatest success has been made by those companies that were not even owners of machine shops of any kind. All the equipment, enumeration and listing that has been going on may be of some use and the so-called "educational" orders may do some good, but the only thing we are sure of is that very little of tradition, precedent or theory is observed in the conduct of a great war.

The suggestions made here for emergency factory construction are to be understood as applicable strictly to emergency conditions, to meet a demand for an unusual amount of ammunition with the least possible delay and in no way as suggestions for permanent private or government arsenal construction. In the construction of the plant, the first point to be considered is the locality with reference to labor supply and transportation. Within easy reach of all our large centers of population may be found level, unoccupied, naturally well-drained acreage that is suitable for the purpose and is grid-ironed by railroads; these are the sole requirements for such a plan. Final inspection, cleaning, painting, toolmaking, etc., will be provided for in fully enclosed one-story buildings at the delivery end of the plant; but the large part of the work will be performed with the lightest kind of shelter over machines, operators and transfer track, and circumstances probably will not always justify even this shelter.

The dimensions of the plant should be determined by the size of shell to be manufactured. Units of a given hourly capacity should be located between and perpendicular to two lines of railroad siding at the ends of the plant; one track will be a receiving track and the other a shipping track. The distance between the tracks will represent the proper length of each unit to avoid congestion and afford the simplest movement and transfer of product. Each unit, commencing at the rear of the plant, will start with an unloading platform and will extend in a double row of opposed machines for the different operations toward the finishing end, where the machinery installation will be replaced by hand operations and inspection, to the packing and shipping track. All machine tools will be horizontally belted, but since space is not considered, the convenience of having all transmission machinery within easy reach is a consideration.

In the construction of the plant, lines of concrete piers will carry the lineshafting; storm-water drains will be placed parallel to these; concrete foundation walls for the machine tools will come next; and transfer tracks will be between the machine foundations. A cutting-compound drain will extend the length of each machine-foundation wall to a sump and pump at the end of the line or at intermediate locations. From each concrete pan under or at the machines, there will extend a chip channel, having a slightly raised bottom, connecting with covered chip tanks sunken in the ground, but readily removable by the cranes. Between each two rows of machines there will be an industrial railway upon which platform cars will be operated; at each machine, car-floor-height platforms will be placed. Such a plant can be erected and operated to capacity within sixty days from the time authority is given to build it.

A complete series of machines for all shell-making operations can be designed along lines that will permit of their construction in immense quantities within thirty days from the time when the necessity for them arises, and at a rate of output that will supply any conceivable demand within the following sixty days. The practicability of such performance has been definitely proved in the last two years; one company accepted orders for hundreds of machines on the guaranteed deliveries of "Commence in thirty days and ship 5 per cent of any sized order every working day thereafter."

The United States government can easily be prepared to deliver such machines in the desired daily quantities within thirty days by the following method: In each selected industrial center establish a government plant in which will be stored the necessary patterns, jigs and equipment to make such machines; and in which will also be kept a list of the plants in the territory equipped to make the required parts. Upon order from Washington, the patterns will be shipped to the designated foundries, and, beginning with the third day, castings should be received at the rate of one casting a day per pattern. It will probably require about three weeks to manufacture the various working parts of the machine, but within thirty days at the outside completed machines will be ready to run in the munitions plants. The number of machines added to the equipment daily will be the same as the number of patterns from which castings are made. This record can be bettered by stocking in the warehouse the various machine parts, aside from the large bed castings, sufficient to make up machines of a desired daily output during the period found necessary. If this is done, completed machines can be delivered to the munition plants within a week of authorization by the government. The total cost to the government for the patterns, jigs and equipment necessary for such a plan of preparedness will be approximately but $1,000,000.

Retrospection on the days of 1915, when manufacturers were begging for standard machine tools with which to make shells and were given deliveries of eight to eighteen months, shows the necessity for an entirely different provision of emergency machines. To depend at all on current stocks or to hope to utilize to any extent the working equipment of existing shops is equally ill-advised. To cut from new cloth in such an emergency as wartime conditions is the only method that promises success, and there is promise of nothing but disappointment in the attempt to adapt existing shops and machinery.

[1]Abstract of a paper read before the American Society of Mechanical Engineers, at Cincinnati, May, 1917, by Lucien I. Yeomans, of Chicago, Ill.

* * *

THE CASUALTY LIST OF PEACE

In calling attention to the great waste of human life in our industries, Secretary Redfield touched upon a subject which is still very much alive, in spite of all the efforts that have been made to safeguard the workers in the industries. The enormous loss due to industrial accidents can perhaps be grasped in no better way than by comparing it with the losses on the battlefield. We read that during the month of August 20,000 British soldiers were killed at the front. This is an appalling number for a month when no great battle took place, and yet the number of men killed in the peaceful industries in the United States during a year is estimated to exceed this number by 50 per cent. During the same month, over 100,000 British soldiers were wounded, but the monthly average in the industries in the United States is 250,000, or two and one-half times that of the whole British army at the front.

We are prone to give our attention to the spectacular and to forget that which does not force itself upon our attention. In a few months, we shall probably be greatly concerned over the casualties at the front, but we shall forget the much greater casualties that constantly, from year to year, take place in our factories and industries at home, a large percentage of which are preventable. It should not be forgotten that the men and women behind the lathes and looms are just as necessary to the prosecution of the war as the men behind the guns, and while every effort is being made to prosecute the war at the battle front properly, the efforts to safeguard the workers at home should be doubled. In spite of all that has been done in the last few years, there are still too many dangers to which industrial workers are exposed that could be eliminated, providing the indifference and ignorance of both those in charge and of the workers themselves could be successfully combated.

PRODUCTION OF ALCOHOL FROM SAWDUST

Arthur D. Little stated before the Canadian Manufacturers' Association, in discussing the production of alcohol from wood waste, that in 1819 Braconnot boiled up some cellulose in the form of an old shirt with sulphuric acid and found that the cellulose was converted into a sort of sugar, some of which he subsequently fermented into alcohol. He exhibited his results to the French Academy to the amazement of its members. A hundred years of industrial research has at last transformed that laboratory method into a commercially operative process, by which thousands of gallons of high-grade ethyl alcohol are made from yellow pine sawdust. This is not wood alcohol, but is identical in every particular with that commonly made from grain. The industrial importance of this achievement can hardly be overestimated. A cord of sawdust costing fifty cents yields ten gallons of 95 per cent alcohol, whereas a bushel of corn costing over eighty cents yields only two and one-fourth gallons, and a gallon of molasses worth at least fifteen cents gives only half a gallon of alcohol. By this process any vegetable waste that can be collected cheaply and in quantity becomes a raw material for alcohol and releases for their proper use as a food the corn and molasses now diverted to alcohol production. Incidentally it removes substantially all menace of a possible failure of the gasoline supply, since alcohol is equally available as a motor fuel.

The Forest Service of the U. S. Department of Agriculture has issued a bulletin declaring that there is no reason for discriminating against ethyl alcohol made from wood in favor of that from grain or molasses. The amount of impurities in commercial ethyl alcohol is very small, and they are probably less objectionable when wood is used as a base than when grain or molasses is used. The prejudice against the use for some purposes of ethyl alcohol made from wood is probably accounted for, the experts say, by a confusion with methyl or "wood" alcohol, which is poisonous. Both products are derived from wood, but are radically different. The ethyl, or grain alcohol, is made by reducing the wood to sawdust, treating the sawdust with an acid to produce chemical sugars, and converting the fermentable sugars into alcohol by fermentation, as in the case of grain or molasses. Wood alcohol, however, is obtained by condensing certain gases which are liberated when the wood is heated in air-tight retorts, so that it decomposes without burning. Ethyl alcohol has been commercially manufactured from wood in this country for several years. It is suitable for any use to which ethyl alcohol from any other base is put. Improvements on the processes that have been developed at the Forest Products Laboratory have made it possible to decrease the former cost of production.

* * *

GAS AND FLAME SERVICE

The Thirtieth Engineers, headquarters Camp American University, D. C., is in need of expert mechanics and chemical workers for the Gas and Flame Service Regiment. The regiment is being recruited now from men volunteering for the service and will be ready to go to France by Thanksgiving. It is a regiment for skilled, practical men and the service offers a real chance for red-blooded Americans to get in where their efforts will give definite results. Those who can qualify are analytical, research and manufacturing chemists, chemical workers, powdermen, men experienced in gas manufacture, machinists, automobile repair men, gas and steam engine repair men, pipe fitters, electricians, designers, carpenters, blacksmiths, plumbers, boiler-makers, chauffeurs, and interpreters. Men with long experience in their trades are especially desired to fill the master engineer grades. American citizens with the above qualifications between the ages of eighteen and forty years, who have not actually been called by a local board in the draft, are eligible for enlistment. Colonel A. A. Fries, Engineers, N. A., is the commanding officer, and Major E. J. Atkisson, Corps of Engineers, is organizing the first battalion at Camp American University, D. C. Those who enlist may go to the nearest recruiting station or United States district engineering office and state their qualifications and wish to enlist in the Thirtieth Regiment of Engineers, Gas and Flame Service.

JOSEPH T. RYERSON & SON CELEBRATE SEVENTY-FIFTH ANNIVERSARY

The firm of Joseph T. Ryerson & Son, Chicago, Ill., celebrated its seventy-fifth anniversary November 1. The Ryerson family has been associated with the iron industry for a much longer period than seventy-five years, however. In the early years of the eighteenth century George Ryerson and associates purchased 6000 acres in New Jersey in which there were deposits of iron ore. These deposits were mined from 1750 to 1770, and the ore was used in the crude processes of iron manufacture then in vogue. Thomas Ryerson became a wholesale dealer in finished iron and steel products in Philadelphia in 1790, and his son, Joseph T. Ryerson, went to Chicago in 1842, where he established the present firm. At that time Chicago was a city of only 6000 inhabitants, having but a few brick buildings, the remainder being rough frame structures. Mr. Ryerson's venture was successful and he erected additional buildings as more and more space was required. After his death, the firm was incorporated, and his son, Edward L. Ryerson, became the president. Three of his grandsons are vice-presidents of the concern. Large plants have been erected at Chicago, New York and St. Louis, and another plant was opened in Detroit on the seventy-fifth anniversary.

* * *

GREAT SHIPBUILDING PLANT AT FORE RIVER

The United States Government has appropriated $80,000,000 for the construction by the Fore River Shipbuilding Corporation, Quincy, Mass., of a $9,000,000 plant and a minimum of forty-six destroyers. The destroyers will cost approximately $1,500,000 each. The construction work on the plant will be done by the Aberthaw Construction Co. of Boston. The buildings to be erected will afford an aggregate floor space of more than 2,000,000 square feet. A tremendous amount of steel will be required for the construction of the reinforced concrete buildings and the destroyers, but the material will not be lacking, since the Priority Board has given the destroyer building preference over all other requirements of concerns working for the government, even over shipbuilders constructing the merchant fleet. The construction of the plant will require more than 4000 men, and for the construction of the destroyers the Fore River Shipbuilding Corporation will need from 8000 to 10,000 men at Quincy, about 3500 at Buffalo, and 1000 at Providence.

* * *

NEW AIRPLANE RECORD IN AMERICA

A new American airplane record was made on October 22, when a Caproni biplane carried nine persons 330 miles in four hours and twenty-five minutes. A Pomilio scout biplane, which left at the same time and carried two persons, made the trip in two hours and fifty-five minutes. Both airplanes are machines the Italian government has sent here to show their capabilities and are in charge of Italian officers; in the flight from the Langley field, near Norfolk, Va., to Mineola, L. I., each carried representatives of the Italian and American armies. The Caproni biplane has a wing spread of 72 feet and is equipped with three Isotta 150-horsepower engines. It made an average of seventy-three miles an hour and flew at about 5000 feet, so as to follow the coast line; part of the trip, however, was made at an altitude of 11,500 feet. The Pomilio biplane is equipped with a 350-horsepower engine, a machine-gun platform, and places for six 65-pound bombs. It flew at a height of 12,000 feet and averaged 112 miles an hour, though sometimes a speed of 140 miles was reached.

* * *

A training school for women oxy-acetylene welders has been established at Notting Hill Gate in England, the expenses in connection with which are paid by the British Government. About two hundred skilled women welders have been trained in this school and at least twenty women are constantly in training. The trained women are successfully carrying out welding work in airplane factories, and the demand for them is so great that so far all the welders have been engaged by the various factories two or three weeks ahead of the completion of their course of instruction.

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Cutters that stand up under hard service for long periods between resharpenings not only minimize the production-lowering periods of inactivity while cutters are taking trips to the grinding wheel, but the profit-earning life of such cutters is considerably lengthened. That's why Brown & Sharpe Cutters not only boost production but lower cutter costs.

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Catalog 27—A Reliable Guide To a Reliable Cutter Service

Providence, R. I., U. S. A.

REPRESENTATIVES: **Baltimore, Md.**, Carey Machinery & Supply Co. **Cincinnati, O., Indianapolis, Ind.**, the E. A. Kinsey Co. **San Francisco, Cal.**, Pacific Tool & Supply Co. **Cleveland, O., Detroit, Mich.**, Strong, Carlisle & Hammond Co. **St. Louis, Mo.**, Colcord-Wright Machinery & Supply Co. **Seattle, Wash.**, Perine Machinery Co. **Portland, Ore.**, Portland Machinery Co.

TRADING WITH THE ENEMY ACT

Secretary William C. Redfield of the Department of Commerce and Labor, Washington, D. C., addressed about two hundred editors at the editorial conference held at the Automobile Club of America in New York City, October 16, on the subject "Trading with the Enemy Act." He spoke, in part, as follows:

The ways of commerce are commonly the ways of peace, but now commerce is used as a war weapon in two ways: first, to provide the nations associated with us in the war with the means of warfare; second, to see that our enemies do not, by direction or indirection, obtain anything that comes from our shores that we can prevent. A third element is conservation, or the saving of that which is not plentiful for use that must be made of it in the war, and the using, on the other hand, of that which is abundant in its place. We are not certain that we are going to have enough for ourselves, our associates and the neutrals to whom it seems to be safe to sell any goods in these days. Consequently, the principle that lies behind the restriction of exports is the principle of conservation.

The restriction of the act will exist whether there is any act or not. It has long been the law of nations that in time of war all communication with the enemy is prohibited. The prohibitions of the act are clearly stated and made plain by the language of the law—but they existed before. There is in the bill, however, an original clause; that is, the creation of the alien property custodian, to whom all debts, interest, dividends, etc., belonging to enemies or enemy allies can be paid, and a full discharge thereby had of the debt.

An American citizen, also, may obtain, providing Germany will reciprocate, patents in an enemy country during the war, and our enemies may obtain patents in this country. Any American manufacturer or industry may apply to the War Trades Bureau for a license to use, during the war, any patent belonging to an enemy or an ally of the enemy existing and valid in this country. He may use the patent if he secures a license for a small fee, but he must pay to the alien patent custodian 5 per cent of the value of the articles that he makes under that patent. At the end of the war, the foreign owner may sue in our courts, within a year, for a royalty for the use of that patent, and if he recovers, this 5 per cent fund, so far as it goes, will be used to pay the judgment; if he does not recover, or if during the year he does not bring suit, the 5 per cent will be refunded to the American user.

* * *

MECHANICS WANTED FOR ORDNANCE CORPS

The Enlisted Ordnance Corps, National Army, into which the Ordnance Enlisted Reserve Corps has been merged, is charged with the supply, maintenance and repair of all cannon and artillery vehicles and equipment; all machines for the service and maneuver of artillery; all small arms, ammunition, harness, motor trucks, motorcycles, tractors and railroad cars. In fact, it is the army behind the army, commonly known as the "Service of the Rear."

There is a place in the Enlisted Ordnance Corps for practically every sound man between the ages specified, who knows a trade. Machinists, mechanics, plumbers, painters, carpenters, canvas workers, motor car repair men, saddlers, blacksmiths and wheelwrights are especially needed at this time. Applicants must be between eighteen and forty years, citizens or declarents, and be able to speak, read and write the English language. They should have no absolute dependents and must be able to pass a physical examination conforming to that prescribed for the regular army.

In view of the importance of their work, a large number of men will serve as non-commissioned officers. Original enlistment is required as private, but later courses of training or special qualifications quickly lead to higher grades. Pay ranges from $30 to $97.20 a month, depending upon the demonstrated ability and place of service. Men registered under the Selective Service Law may voluntarily enlist prior to the posting of their names by the local boards. Application blanks may be obtained by writing to the Chief of Ordnance, Enlisted Personnel Division, Washington, D. C.

PERSONALS

Robert T. Turner has joined the Shepard Electric Crane & Hoist Co. as sales engineer at 30 Church St., New York City.

P. J. Kroll has resigned as representative of the International Oxygen Co., 115 Broadway, New York City, for Pittsburg and the middle western territory.

Murray Shipley and Henry M. Wood, formerly with the Lodge & Shipley Machine Tool Co., Cincinnati, Ohio, have joined The Sechler & Co., Cincinnati, Ohio.

C. W. Johnson, general superintendent of the East Pittsburg Works of the Westinghouse Electric & Mfg. Co., has been elected vice-president of the American Institute of Metals.

C. F. Goodrich, assistant manager of the Buffalo Forge Co.'s Boston office, has left for active duty as first lieutenant in the Ordnance Department, and is stationed at the Watervliet Arsenal.

Hans Karlsrud, representing A/S. National Industri in the United States, has returned to Norway, and the interests of the company will be in charge of Bjarne Holm-Hansen, 309 Broadway, New York City.

Charles C. Cheyney, manager of the Chicago office and store of the Buffalo Forge Co., has a commission in the Naval Aeronautic Corps, and is beach engineer at Pensacola, Fla., in charge of aeroplane engines.

B. D. Fuller, superintendent of foundries of the Westinghouse Electric & Mfg. Co., East Pittsburg, Pa., was elected president of the American Foundrymen's Association at the recent annual convention in Boston.

Edmund Barany, machine designer of the Singer Mfg. Co., Elizabeth, N. J., has assumed the duties of mechanical engineer and assistant to the general superintendent of the Cleveland Twist Drill Co., Cleveland, Ohio.

Don R. Marsh, production manager with the Buffalo Forge Co.'s Buffalo office, has given up his work to assume similar duties at Washington in the production of ammunition. Mr. Marsh received a captain's commission.

H. F. Bardwell, well known to buyers of tool steel in the East, has been appointed New York district manager for the Vanadium-Alloys Steel Co. of Pittsburg and Latrobe, Pa. Mr. Bardwell's offices will be at 30 Church St., New York City.

N. C. Walpole, southern sales manager of the Niles-Bement-Pond Co. and the Pratt & Whitney Co., with office in Birmingham, Ala., has been granted leave of absence for the duration of the war. He has been commissioned major in the Ordnance Department.

Edmund B. Moore, for the last six years demonstrator with the Jones & Lamson Machine Co., has been commissioned as first lieutenant in the United States Army, Ordnance Section. Mr. Moore is a graduate of the Massachusetts Institute of Technology in the class of 1912.

Charles O. Rowe has joined the sales force of the Hess Steel Corporation, Baltimore, Md. Mr. Rowe was formerly associated with the Union Drawn Steel Co. in the sales department. He will act as representative for the Philadelphia district for the Hess Steel Corporation.

Frederic Meron, a mechanical and electrical engineer who has given much attention to efficiency methods of production, has opened an office at 2 Rector St., New York City, where he will give attention to lay-outs, location of machinery and equipment, the handling of materials, working methods, industrial accounting and other problems in industrial engineering.

H. F. Brandes, who for the past four years has been works manager of the Putnam Machine Co., Fitchburg, Mass., has resigned. He directed the erection and equipment of the new plant of the Putnam Machine Co., which is considered one of the most modern in the country. Mr. Brandes has returned to Bridgeport for the present to give his attention to his interests in the Springfield Mfg. Co.

J. F. Sallows, Lansing, Mich., a heat-treatment expert and occasional contributor to MACHINERY, has worked out a method for hardening carbon steel gears and other parts whereby they hold their size and shape in every way. There is no warping, shrinking, swelling or scale; the holes in gears do not require grinding after hardening, and may be broached to exact size before hardening.

William A. Battey, who has been connected with the Shepard Electric Crane & Hoist Co., Montour Falls, N. Y., as Eastern sales manager and sales director since its start in this field, has resigned; his resignation is to take effect December 1. He will retain his interest in the company and continue as a director. W. C. Briggs, who for the past ten years has been associated with Mr. Battey in the company's New York office as sales engineer, will become district manager.

Cincinnati Gauging and Inspection Methods

Interchangeability of machine parts is a very flexible term. Even the parts of agricultural machinery are interchangeable, which shows that this word may mean much or little. In machinery construction it must be used in connection with stated or known accuracy limits. The limits to which parts of Cincinnati Millers are made vary from .001″ on some parts to .00025″ on others, and in many cases no tolerance is allowed. When such parts are made interchangeable, the gauging and inspection methods must be rigid.

Gauging Unit Mechanisms—Our unit system of construction demands different gauging methods from those usually employed. Figure 1 shows a set of gauges for testing the alignment of the splined shafts in milling machine knees. This is tested by two indicators, one reading on the top and the other on the side of a master shaft, inserted in the knee. Before making the test, these indicators are set to the master gauges, shown on top of case. This gives us a permanently accurate method of testing, which shows us more closely than any fixed or snap gauge can do whether a shaft is parallel and in its proper position, or in wind and out of position.

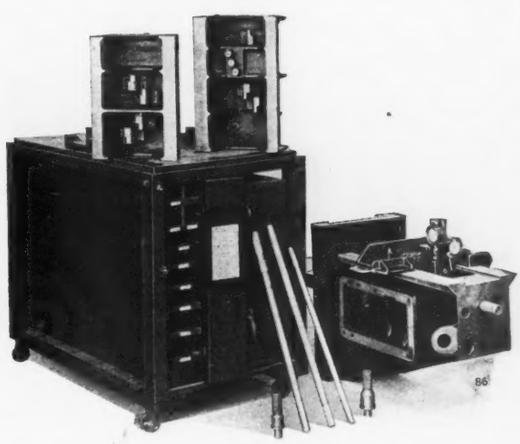

Fig. 1

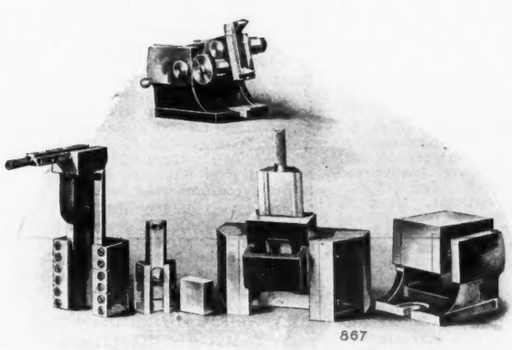

Fig. 2

The Testing Gauges for Our Dividing Head Tailstocks—These tailstocks consist of four parts, all of which slide into each other accurately. These parts are manufactured in lots of fifty. They are absolutely interchangeable in the machining stage, and can be pushed together without any hand work. The final scraping, which merely removes the loose iron, serves to give them a snug sliding fit.

These are only two examples out of manyhundreds which we use. You are welcome to inspect these things in our factory at any time.

Let us send you our catalog showing the full line of Millers made by these methods.

THE CINCINNATI MILLING MACHINE CO.

CINCINNATI, OHIO, U. S. A.

COMING EVENTS

November 29—Monthly meeting of the Rochester Society of Technical Draftsmen, in Rooms 131-137, Sibley Block, 328 Main St., E., Rochester, N. Y. O. L. Angevine, Jr., secretary, 857 Genesee St., Rochester.

December 4-7—Annual meeting of the American Society of Mechanical Engineers in New York City; Engineering Societies Bldg., 29 W. 39th St., headquarters. Calvin W. Rice, secretary.

NEW BOOKS AND PAMPHLETS

The Effect of Mouthpieces on the Flow of Water through a Submerged Short Pipe. By Fred B. Seely. 49 pages, 6 by 9 inches; 14 illustrations and diagrams. Published by the University of Illinois, Urbana, Ill., as Bulletin No. 96 of the Engineering Experiment Station. Price, 25 cents.

Merchants' Association of New York Year Book 1917. 272 pages, 7 by 10 inches. Published by the Merchants' Association of New York, Woolworth Bldg., New York City.

The year book covers the activities of the association for the period from May 1, 1916, to April 30, 1917, and contains the reports of the president, the secretary and the managers of the various bureaus. It also has alphabetical and classified lists of the members, which should be found especially helpful.

The Secret of Typewriting Speed. By Margaret B. Owen. 157 pages, 5 by 7½ inches. Published by Forbes & Co., Chicago, Ill. Price, $1.

This book, by the world's champion typist, belongs with the literature on scientific management, as it embodies the principles of efficiency of action and the elimination of lost effort in typewriting. The marvelous speed capacity of the typewriter when operated by one who has studied the science of key action is indicated by the fact that Miss Owen has written 137 words a minute for one hour.

Graphics. By H. W. Spangler. 95 pages, 6 by 9 inches. Published by John Wiley & Sons, Inc., 432 Fourth Ave., New York City. Price, $1.25.

The work comprises the substance of lectures on graphics given to students in mechanical, electrical and chemical engineering at the University of Pennsylvania, and is intended to cover only fundamental principles. It includes a brief treatment of trusses, and sufficient of the graphics of machines to clearly set forth the effective friction on the line of action of force to be determined, taking for one example the friction of gear teeth. Application to the stresses in crankshafts is also included.

American Stationary Engineering. By W. E. Crane. 311 pages, 5 by 7½ inches; 131 illustrations. Published by Norman W. Henley Publishing Co., 132 Nassau St., New York City. Price, $2.

This is the second edition of a book first published in 1910 which begins at the boiler room and takes in the whole power plant. The author emphasizes the practical side of stationary engineering and exhibits some scorn of the professed expert, although he has not hesitated to avail himself of much that has been developed by specialists in their various capacities. The book is one that should be found helpful by firemen and young engineers ambitious to better their conditions.

Learning to Fly in the U. S. Army. By E. N. Fales. 180 pages, 5 by 7¼ inches; 40 illustrations. Published by McGraw-Hill Book Co., Inc., 239 W. 39th St., New York City. Price, $1.50, net.

This book is a manual of aviation practice, and is well suited for the aeronautic instruction of the large number of men that have joined the flying corps since the declaration of war. Many of these men have been called from non-technical occupations, and the book brings forth to the non-technical student the gist of aviation in such a manner that accuracy is not sacrificed to brevity. It contains a review of the history of aviation, the types of military airplanes, and fully explains all that is necessary to know in order to successfully fly and care for a machine, but it does not treat the subject of airplane motors.

Mechanical Drawing Problems. By Charles William Weick. 153 pages, 6 by 9 inches; 48 illustrations; 112 plates and 12 tables. Published by McGraw-Hill Book Co., Inc., 239 W. 39th St., New York City. Price, $1.25, net.

This is a satisfactory book for either school or self instruction. It provides typical drawings for elementary and advanced work, the data of which the student is required to obtain by the use of formulas and tables, thus developing a knowledge of drawing principles and designing ability, and tending to make him more careful in reading directions and the lay-out of his sheets. It contains problems on geometrical constructions, projections, developments and intersections, isometric drawings, machine details, and tables that are useful to draftsmen, which the student is required to use when making the various drawings.

Everyman's Chemistry. By Ellwood Hendrick. 364 pages, 5 by 8 inches. Published by Harper Brothers, 325 Pearl St., New York City. Price, $2.

While this book does not profess to be a complete treatise and is in no sense a laboratory guide, it contains so much information that even a casual reader will obtain some knowledge of the subject. The first part, which contains 56 pages, emphasizes the importance of a knowledge of chemistry and deals with the elements of the subject. The second part, which contains 176 pages, is confined to a discussion of inorganic chemistry. Here the various elements are described and their uses, alone and in their more usual combinations, are given. The third part is devoted entirely to organic chemistry. Among the subjects treated are coal-tar intermediates and finished products; aromatic compounds; cellulose and nitrogen compounds; and fats, oils, and their products.

The Essentials of Descriptive Geometry. By F. G. Higbee. 218 pages, 6 by 9 inches. Published by John Wiley & Sons, Inc., 432 Fourth Ave., New York City. Price, $1.80.

This work as published in 1915 has passed into the second edition. It deals with orthographic projection, profile plane, assumption of points and lines, planes, location of points, lines and planes, revolution of points, problems on the line, problems on the plane, problems on angles, problems on points, lines and planes, surfaces, plane surfaces, cylindrical surfaces, conical surfaces, intersection of surfaces, surfaces of revolution, warped surfaces, tangent planes and lines, and model making. Each chapter concludes with problems involving the principles enunciated therein. The section on warped surfaces is illustrated with easily constructed models which can be duplicated by the student, thus providing visual means for fixing their position in space.

Elements of Machine Design. By O. A. Leutwiler. 607 pages, 6 by 9 inches; 339 illustrations; 107 tables. Published by McGraw-Hill Book Co., Inc., 239 W. 39th St., New York City. Price, $4, net.

This book is a discussion of the fundamental principles involved in the design and operation of machinery. It contains a chapter on the strength of materials and mechanics of machinery, and a chapter discussing the properties of materials used in machine construction. The remaining chapters treat the various elements of machine design, including rope transmission; chains and sprockets; gearing; couplings; cone and multiple disk friction clutches; shafting; and bearings. A special feature is a chapter on brakes. The standard works on this subject, the various engineering societies and the technical press were freely consulted in the preparation of the book. The work is one heartily recommended to all needing a modern work on the elements of machine design.

Saws: Their Care and Treatment. By Harry W. Durham. 272 pages, 4¾ by 7¼ inches; 155 illustrations. Published by D. Van Nostrand Co., New York City. Price, $2.50, net.

This work is on saws for wood-working machines and was written by one who has given the subject careful investigation for twenty-five years, during which time he visited a large number of saw mills and investigated the methods followed in their saw sharpening shops. It opens with general introductory notes on saws, following which are particulars of reciprocating saws and circular saws; notes on sharpening saws by hand filing; saw sharpening machines; setting the teeth of saws; hammering and tensioning circular and reciprocating saws; sharpening large band-saws; the saw sharpening room; small and narrow band-saws; wide band-saws; tensioning, leveling and hammering band-saws; doctoring band-saws, saw packing and saw guides; power required to drive sawing machines; and miscellaneous matters.

Some Unusual Features in the Microstructure of Wrought Iron. By Henry S. Rawdon. 25 pages, 7 by 10 inches; 12 illustrations. Published by the Department of Commerce, Washington, D. C., as Technologic Paper of the Bureau of Standards, No. 97. Price, 5 cents.

Wrought iron is usually described as being of a very simple structure as revealed by the microscope, as compared with many of the alloys in commercial use. A study of the microstructure of a series of commercial wrought irons carried out at the Bureau of Standards, however, has shown the occurrence of some very peculiar and unusual variations in structure in such material. Many of the ferrite crystals, when properly prepared and etched for microscopic examination, show a decidedly banded structure instead of the homogeneous appearance usually described. This unusual structure is to be attributed to a relatively high phosphorus content in such portions and to a non-uniform distribution of this element. Although most specimens showing these unusual features of structure are of a rather poor grade, they are not characteristic of low-grade iron in general. The probable relation between such microstructural features and "fatigue" failure of such material is suggested.

Hendricks' Commercial Register of the United States for Buyers and Sellers. 2378 pages, 7½ by 10 inches. Published by the S. E. Hendricks Co., Inc., 2 W. 13th St., New York City. Price, $10.

The twenty-sixth annual edition of this well-known trade directory contains 2209 pages of text matter, and the index to trade classification covers 151 pages, listing over 50,000 trade references. The section devoted to trade names, brands, titles of identification, etc., is printed on pink paper to differentiate it from the remainder of the book. It covers 212 pages, and furnishes ready reference to distinctive products manufactured by all concerns whose names appear in the work. An alphabetical list of manufacturers is included for the first time. It contains the name, trade description and address of every concern appearing in the work. The scope of this commercial register is broad, being devoted to the interests of the architectural, contracting, electrical, engineering, hardware, iron, mechanical, mill, mining, quarrying, railroad, steel and kindred industries. Full lists are included of producers, manufacturers, dealers and consumers, covering all products from the raw material to the finished article, together with the names of concerns manufacturing these products from the producer to the consumer. The directory is indispensable to concerns who would compile their own mailing lists for the distribution of catalogues and other advertising literature.

NEW CATALOGUES AND CIRCULARS

Standard Optical Co., Geneva, N. Y. Circular of the "Stoco" protection goggles.

General Electric Co., Schenectady, N. Y. Bulletin 41021 on RF adjustable speed motors.

Burt Mfg. Co., Akron, Ohio. Catalogue of oil-filters, exhaust heads and ventilators.

Alloy Die Casting Co., 80 Fort St., E., Detroit, Mich. Pamphlet treating of alloy bronze bearings.

Newark Engineering & Refrigerating Co., 476 18th Ave., Newark, N. J. Circular of the "Nerco" filing machine.

Worthington Pump & Machinery Corporation, 115 Broadway, New York City. Bulletin S-112 of Snow oil pumps.

Gits Bros. Mfg. Co., 553 W. Monroe St., Chicago, Ill. Circular of Gits self-closing spring-lid oil-cups, giving dimensions, prices, etc.

Reed Small Tool Works, Worcester, Mass. Leaflet giving list prices of Reed micrometer calipers from one to six inches, inclusive.

Neilsen-Barton Chuck Co., 106 S. Jefferson St., Chicago, Ill. Circular containing price list of the "Eclipse" roller-bearing drill chuck.

Nagle Corliss Engine Works, Erie, Pa. Bulletin 29, illustrating and describing Class A-E and A-E2 air compressors with short-belt drive.

General Electric Co., Schenectady, N. Y. Bulletin 401801 on motor-driven exhaust fan outfits, driven by direct- and alternating-current motors.

David A. Wright, 568 Washington Blvd., Chicago, Ill. Circular of the Wright "Simplex" bench milling machine with or without overhanging arm.

American Chemical Paint Co., 1118-1126 S. 11th St., Philadelphia, Pa. Circular of the "Deoxidine" process of cleaning steel preparatory to painting.

Worthington Pump & Machinery Corporation, 115 Broadway, New York City. Bulletin W-500 of pot valve pressure pumps, giving sizes and capacities.

Metalwood Mfg. Co., Detroit, Mich. Circular B-32 of Metalwood horizontal forcing presses with hand-operated pump, giving specifications for the 20- and 50-ton sizes.

Remington Arms Union Metallic Cartridge Co., Inc., Bridgeport, Conn. Pamphlet describing the apprentice courses given by the Remington Armory at Bridgeport.

Charles M. Terry, Inc., 23-25 Beaver St., New York City. Catalogue describing and illustrating the Dunbar variable-speed pulley, which entirely eliminates gearing.

Fenn Mfg. Co., 385-405 Broad St., Hartford, Conn. Circular of the Fenn high-speed sensitive drilling machine which gives a maximum spindle speed of 15,000 revolutions per minute.

Peerless Machine Co., Racine, Wis. Circular descriptive of the Peerless high-speed metal saw made in three sizes, having capacities of 6 by 6 inches, 9 by 9 inches, and 13 by 16 inches.

David A. Wright, 568 Washington Blvd., Chicago, Ill. Circular of the Wright 18-inch and 20-inch cone-head engine lathe with independent change-gear and single or double back-gears.

Master Machine Tool Co., 110-112 W. 40th St., New York City. Circulars of the Master 13-inch lathe built with three-step cone pulley and single pulley for constant-speed belt drive.

Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa. Bulletin 860 descriptive of the Leeds & Northrup optical pyrometer, a portable instrument for works temperature measurements.

H. G. Doran & Co., Peoples Gas Bldg., Chicago, Ill. Circular of the B. & D. portable electric drill with pistol grip. The pistol grip with trigger control saves drills and facilitates drilling.

Locke Steel Chain Co., Bridgeport, Conn. Circular entitled "From Planting Time to Harvest," showing uses of Locke steel chain for transmitting power in agricultural machinery.

R. G. Haskins, 541 W. Washington Blvd., Chicago, Ill. Catalogue of portable universal motor drills, motor-driven grinders, "Strand" flexible shaft machines, toolpost equipment, grinders and burnishers.

Bilton Machine Tool Co., Bridgeport, Conn. Circular of the No. 10 Bilton gear-hobber, having a capacity for cutting gears of 10 diametral pitch, 10 inches outside diameter and 10 inches width of face.

Hammel Oil Burning Equipment Co., Inc., 409 Pine St., Providence, R. I. Catalogue of Hammel oil burners and oil burning systems, containing a detailed description illustrated by line engravings and halftones.

Shepard Electric Crane & Hoist Co., Montour Falls, N. Y. Catalogue of the Shepard Technical Night School, containing announcement of courses for 1917-1918. The school is conducted for employes of the company only.

H. G. Doran & Co., Peoples Gas Bldg., Chicago, Ill. Circular of the "Pull-U-Out" portable crane, having a lifting capacity of one ton and weighing only 250 pounds. The crane is portable, being mounted on three wheels.

The LUCAS

(OF CLEVELAND)

"PRECISION"

BORING, DRILLING AND

MILLING MACHINE

ALWAYS GOOD

and as time goes on

ALWAYS BETTER

LUCAS MACHINE TOOL CO., NOW AND ALWAYS OF CLEVELAND, O., U.S.A.

Oliver Machinery Co., Grand Rapids, Mich. Bulletins descriptive of Oliver 23-A patternmaker's wood-turning face lathe, and Oliver 60 universal saw bench with tilting table that can be adjusted to any angle up to 45 degrees.

Gisholt Machine Co., 1211 E. Washington Ave., Madison, Wis., has issued a brief pictorial history of aircraft development up to the modern airplanes; it also shows how the Gisholt turret lathes are used in manufacturing some of the important mechanical parts.

Worthington Pump & Machinery Corporation, 115 Broadway, New York City. Bulletin W-400, illustrating and describing Worthington outside-packed plunger pattern pumps for general service. Catalogue W-308, treating of Worthington duplex piston pattern pumps.

Wirt Co., Germantown, Philadelphia, Pa. Bulletin of "Di-el-ite" resistance units especially adapted for signaling systems, telephone and telegraph work, electrical testing, motor regulations, and other service where durable and rugged resistors are needed.

Boston Scale & Machine Co., 381 Congress St., Boston, Mass. Circular descriptive of a universal angle-plate that can be adjusted quickly to any angle without disturbing the work bolted to it. It has a motion through 360 degrees horizontally and 90 degrees vertically.

Link-Belt Co., Chicago, Ill. Folder 340, descriptive of the machinery designed and built by the Link-Belt Co. for the sand and gravel washery of the Raritan Ridge Clay Co., at Metuchen, N. J. Book 343, descriptive of Link-Belt rope tramway system of the Watson type.

Diamond Machine Co., Providence, R. I. Catalogue entitled "The Diamond on the Job," containing a number of excellent illustrations showing the Diamond heavy face grinding machine in operation on various jobs, and giving briefly the essential facts concerning its performance.

Springfield Machine Tool Co., 631 Southern Ave., Springfield, Ohio. Catalogue of standard engine lathes, 14- to 42-inch swing; brass working lathes; axle boring lathes; crank shapers, 12- to 20-inch stroke; back-geared pillar shapers, 16-, 20- and 25-inch stroke; and bench straightening presses.

American Steel Export Co., Woolworth Bldg., New York City., has issued a 24-page pamphlet giving the groups of countries and lists of materials affected by the president's proclamation and subsequent orders, together with facsimiles of forms prescribed and explanation of their use.

Walter A. Zelnicker Supply Co., 325 Locust St., St. Louis, Mo. Bulletin 220, containing lists of new and second-hand girder rails, locomotives, railway cars, trucks, steam shovels, air compressors, steam engines, electric light outfits, machine tools, steel piling, pressure tanks and other equipment.

Armstrong Cork & Insulation Co., Pittsburg, Pa. Folder describing a test made to determine how much fuel could be saved by the use of an effective heat-insulating material in boiler settings, and the results obtained by the use of "Nonpareil" insulating brick. Copies will be sent free upon request.

Elgin Tool Works, Elgin, Ill. Catalogue 5 of precision bench lathes, slide-rests, milling attachments, screw-cutting attachments, dividing and indexing attachments, planing and slotting attachments, vises, chucks, lathe collets and light bench machinery. A number of new tools are included in this catalogue.

E. C. Atkins & Co., Indianapolis, Ind., manufacturers of "silver steel" saws, are issuing a folder entitled "The Straight Road" to the members of the Atkins Silver Steel Saw Club. The club is composed of several thousand retail hardware salesmen, and folders containing sales talks are sent out to the members about every sixty days.

Vulcan Iron Works, 327 N. Irving Ave., Station D, Chicago, Ill. Circular 44 of portable hydraulic presses for machine shops, railway and contractors' shops. The No. 2 press has a capacity of 60 tons, and the No. 3 press of 100 tons. The No. 2 size is ordinarily used for machine shop work. This size weighs 1600 pounds and sells for $200.

American Steel Export Co., Woolworth Bldg., New York City, has issued a new pamphlet entitled "Utility Letters of Credit in the Export Trade—A Plea for Standard Forms," by J. P. Beal, secretary and assistant treasurer of the company. The pamphlet makes recommendations for standard forms that should receive the attention of American bankers and exporters.

Diamond Machine Co., Providence, R. I. Catalogue of disk grinding machines of various types and sizes. These machines are made with right- and left-hand plain tables, with right- and left-hand swinging tables, and with single tables either right- or left-hand. The grinding disks are 18, 20, 26 and 30 inches in diameter, and the chucks are made in 14- and 22-inch sizes.

Simonds Mfg. Co., Fitchburg, Mass., has just issued a little booklet illustrating and describing various styles of solid and inserted-tooth metal saws entitled "Methods of Cutting Metal." The booklet contains sixty-four pages of information on metal cutting, covering the use of each saw and the sizes furnished, the teeth, speed and feed, and details which should be given when ordering them.

Prest-O-Lite Co., Inc., 837 Speedway, Indianapolis, Ind. Bulletin entitled "Turning Waste into Profit," showing many examples of broken machinery parts that were successfully welded by the Prest-O-Lite oxy-acetylene apparatus. The bulletin is of interest to all users of machinery and valuable to oxy-acetylene welding operators, as it shows a variety of work done and methods of preparing for welding. It contains eighty-two illustrations representative of reclamation welding work in practically every field of the industrial world. In the face of present high prices and scarcity of metal equipment, the subject of welding is receiving more than usual consideration, as it enables plant owners to hold down the scrap heap.

TRADE NOTES

Warren F. Fraser Co. has moved its plant from Boston to Westboro, Mass.

Reynolds Machine Mfg. Co., Massillon, Ohio, has changed its name to Reynolds Machine Co.

Laughlin-Barney Machinery Co., Pittsburg, Pa., has removed its offices to 481 Union Arcade.

Victor Saw Works is the new name of the Massachusetts Saw Works of Springfield, Mass., manufacturers of "Victor" hacksaw blades.

M. Mett Engineering Co., New York City, has moved from Hotel Vanderbilt to 1 Madison Ave. J. M. Wimpie is the American representative.

Worthington Pump & Machinery Corporation, 115 Broadway, New York City, has opened a new branch sales office in the American Trust & Savings Bank Building, Birmingham, Ala., to take care of part of the territory hitherto controlled by the Atlanta office. Edward Stauverman, formerly with the Atlanta office, will be in charge.

Macleod Co., Cincinnati, Ohio, which has been established for over twenty years in the manufacture of sandblast equipment and metallurgical furnaces, has recently enlarged its plant and increased its capital to $100,000. The larger facilities and increased capital were required to take care of the company's rapidly expanding business.

Onondaga Steel Co., Syracuse, N. Y., has nearly completed a new plant in East Syracuse which provides floor space and new equipment that will increase the capacity ten-fold. The company is engaged exclusively in converting high-speed steel scrap into merchantable steel bars by the Onondaga process.

Davis-Bournonville Co., Jersey City, N. J., has opened a sales office in the Colorado Bldg., Washington, D. C., with Henry R. Swartley, Jr., resident manager. The Washington office will facilitate the company's business with the government, which is a large user of oxy-acetylene welding and cutting apparatus in both army and navy.

Parker Mfg. Co., Inc., manufacturer of drill chucks, has moved from Detroit, Mich., to Ann Arbor, Mich. The company is incorporated with $75,000 capital, and has purchased the plant formerly owned by the Star Motor Co. on East Summit St. It is expected that over one hundred men will be employed when the plant is in full operation.

Herman A. Holz, 1 Madison Ave., New York City, was not awarded the Edward Longstreth Medal of Merit by the Franklin Institute, for his portable Brinell meter, as stated in the October number. The medal was awarded for the invention of a portable Brinell meter to Frank H. Schoenfuss and Albert Ringland, of Philadelphia, who are the joint inventors of the instrument.

Porter-Cable Machine Co., Syracuse, N. Y., has purchased a five-story brick building at N. Salina and Wolf Sts., 60 by 200 feet, and affording 60,000 square feet floor space. The entire building will be devoted to the manufacture of the Porter-Cable manufacturing lathe. Extensive alterations will be made in the building and the plant will be ready for occupancy about December 1.

Brown Instrument Co., Philadelphia, Pa., has purchased a large plot of land located on the south side of its factory to provide for extensions to the plant made necessary by the unusual demand for Brown pyrometers and other scientific instruments manufactured. The property of the company now extends along Wayne Ave. from Windrim Ave. on the north to Roberts Ave. on the south.

Long & Allstatter Co., Hamilton, Ohio, manufacturer of shearing and punching machinery, has purchased the shearing business, patterns, etc., of Thomas Carlin's Sons, Pittsburg, Pa. The equipment will be merged with that in the works at Hamilton, Ohio. Thomas Carlin's Sons was one of the oldest concerns engaged in this line of manufacture, the business having been established in 1854.

Cleveland Planer Works, 3150-3152 Superior Ave., Cleveland, Ohio, manufacturers of "Cleveland" open-side planers, have been incorporated as the Cleveland Planer Co., with a capital of $300,000. George W. Ford, partner with James G. Dornbirer, has sold his interest, and a corporation has been formed. The officers are Frank S. Shields, president; J. A. Camm, vice-president; J. L. Whitelaw, treasurer; and James Sarrell, secretary. James G. Dornbirer is manager.

E. P. Reichhelm & Co., Inc., 24 John St., New York City, representative of the American Gas Furnace Co. and the American Swiss File & Tool Co., has purchased the six-story marble-front building at 26 John St., using Liberty bonds in payment. The building is on a plot 25 by 70 feet. The officers of the company are E. P. Reichhelm, president; P. F. Reichhelm, vice-president; E. H. Brownell, treasurer; and Charles A. Leibman, secretary and assistant treasurer.

National Bank of Commerce, 31 Nassau St., New York City, has issued a pamphlet containing the complete official text of the war tax law, together with the income tax law in its amended form, the title being "War Revenue and Federal Income Tax Laws." The provisions of the law are arranged in such a manner that they may be readily referred to by busy men. The pamphlet is one of a series of official laws that have been issued from time to time by the National Bank of Commerce.

Westinghouse Electric & Mfg. Co., East Pittsburg, Pa., announces another wage increase for shop employes aggregating nearly $2,000,000 a year, which became effective October 16. All employes observing shop hours, except munition workers, will receive an additional bonus of 10 per cent if they are on a salary or time-rate basis, and of 7 per cent if they are on a piece, premium or task basis. This will affect about 20,000 employes of the company. Since the outbreak of the war these employes have received increases amounting to about 60 per cent of the former average compensation.

Buffalo City Line Realty Co., Buffalo, N. Y., a subsidiary of J. H. Williams & Co. of Brooklyn, N. Y., manufacturers of drop-forgings, has sold to the United States government a plot of between 12 and 20 acres, having a depth of 1320 feet and a frontage of 400 to 600 feet on Vulcan St. at the city line in Buffalo, as a site for the government-owned manufacturing plant which is being erected for the building of steam turbines. The turbines are for the torpedo boat destroyers provided for in the Urgency Deficiency Bill. The plant will employ between 2000 and 3500 men and will be operated by the Fore River Ship Building Corporation.

Fairmount Tool & Forging Co., 10585-10611 Quincy Ave., Cleveland, Ohio, is a new concern recently organized to manufacture hand- and drop-forged tools for motor cars, motor trucks, tractors, airplanes, etc. The officers are J. Wentworth Smith, president; B. G. Gilmore, vice-president and sales manager; Charles W. Yarham, secretary and treasurer. The management of the company has been associated with the tool manufacturing business for the last ten years, particularly the tool equipment supplied by the motor car manufacturers for their cars. A factory affording 16,000 square feet of floor space with ample room for expansion has been provided.

Vulcan Steel Products Co., 120 Broadway, New York City, has opened an office in Havana, to take care of its rapidly growing business in Cuba. The company's branches or agencies are now established over the principal trade centers of the world. Branch offices are maintained at Paris, Hongkong, Shanghai, Yokohama, Milan, Barcelona, Melbourne, Sydney, San Juan, Singapore, and Havana. The company is also represented by well-known business houses in London, Brazil, Portugal, Argentine, Uruguay, Paraguay, Peru, Chile, Bolivia, and Venezuela. Within a year from its incorporation in September, 1916, the company built up an export business in steel and iron, machinery and similar lines, which in August alone amounted to $8,000,000.

New Remington Rifle Co., Bridgeport, Conn., was organized under the laws of the state of Connecticut early in September. Under the terms of its charter it can manufacture, buy, sell and deal in firearms of every description. It is expected that the company will continue the manufacture of Russian rifles which work was heretofore carried on by the Remington Arms Union Metallic Cartridge Co., and the manufacture will be carried on in the plant established by the Remington Arms Union Metallic Co. in Bridgeport. The directors of the new company are Samuel McRoberts, Henry S. Kimball, William E. Griswold, P. A. Morosoff, R. Poliakoff, and F. W. Abbot. The officers are Henry S. Kimball, president; James T. Anyon, treasurer; and John P. Murray, secretary.

New Departure Mfg. Co., Bristol, Conn., held a barbecue and field day for its employes September 21, which was attended by three thousand people. At four o'clock in the morning the chefs built their fires and began preparing for the dinner. At noon there was a parade, led by an employes' band, in which all the different departments of the company were represented. The parade marched through the center of the city and ended at a grove, where there was served an excellent dinner of barbecued lamb, roasted and browned for eight hours, and all the fixings that go with it. While the dinner was in progress, an entertainment consisting of vocal solos and a concert by the band was provided. Afterward there were athletic contests, prizes being given to the winners, and ball games between the various plants of the concern. Moving pictures were taken of the event, which will be shown in a local theater.

Davis-Bournonville Co., Jersey City, N. J., has taken over the plant and factory of the Davis Acetylene Co., Elkart, Ind. The Davis Acetylene Co. has been dissolved and the manufacture of acetylene lighting generators and accessories discontinued. The plant will hereafter be operated under management from Jersey City for the manufacture of acetylene pressure generators for the oxy-acetylene process, and for special products. The Canadian factory at Niagara Falls, Ontario, which has been jointly occupied by the two companies, has also been taken over and will be operated exclusively for the manufacture of oxy-acetylene apparatus for the Canadian trade. The Davis-Bournonville Co. has also purchased the H. G. Kotten Co. factory and land adjacent to its Jersey City property. This factory will be used for manufacturing electrolytic oxygen apparatus and accessories. A four-story warehouse, 60 by 100 feet, of brick and mill construction, will be immediately erected on the Kotten property, and a five-story factory, 60 by 150 feet, corresponding to the company's No. 3 factory recently completed, will be erected during the coming year.